Risks of Diazinon Use to the Federally Listed California Red Legged Frog
(*Rana aurora draytonii*)

Pesticide Effects Determination

Environmental Fate and Effects Division
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1. Executive Summary

The purpose of this assessment is to evaluate potential direct and indirect effects on the California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of diazinon on agricultural and non-agricultural sites. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' designated critical habitat. This assessment was completed in accordance with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) *Endangered Species Consultation Handbook* (USFWS/NMFS, 1998 and procedures outlined in the Agency's Overview Document (U.S. EPA, 2004).

The CRLF was listed as a threatened species by USFWS in 1996. The species is endemic to California and Baja California (Mexico) and inhabits both coastal and interior mountain ranges. A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996) in California.

Currently, labeled uses of diazinon include several fruit, nut, and vegetable crops as well as cattle ear tags. The following uses are considered as part of the federal action evaluated in this assessment: almonds, blueberries, caneberries, cattle ear tags, cranberries, fig, ginseng, leafy vegetables (spinach, endive), lettuce, melons (cantaloupes, casabas, crenshaws, honeydews, muskmelons, Persians, watermelons), pineapples, root crops (onions, radishes), row crops (carrots, beans, peppers (bell and chili), peas (succulent), beets (red)), strawberries, tomatoes, tree fruit (apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes), and tuber crops (rutabagas and sweet potatoes). Use of diazinon on ornamental plants in nurseries is also included in this evaluation. Uses of diazinon on ginseng, cranberry and pineapple are not relevant to this assessment, since these crops are not grown in California.

The environmental fate properties of diazinon along with monitoring data identifying its presence in surface waters, air, and in precipitation in California indicate that runoff, spray drift, volatilization, atmospheric transport and subsequent deposition represent potential transport mechanisms of diazinon to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of diazinon from initial application sties through runoff and spray drift are considered in deriving quantitative estimates of diazinon exposure to CRLF, its prey and its habitats. Although volatilization of diazinon from treated areas resulting in atmospheric transport and eventual deposition represent relevant transport pathways leading to exposure of the CRLF and its habitats, adequate tools are not available at this time to quantify exposures through these pathways. Therefore, volatilization, atmospheric transport and wet and dry deposition from the atmosphere are only discussed qualitatively in this assessment.

Since CRLFs exist within aquatic and terrestrial habitats, exposure of the CRLF, its prey and its habitats to diazinon are assessed separately for the two habitats. Tier-II aquatic exposure models are used to estimate high-end exposures of diazinon in aquatic habitats resulting from runoff and spray drift from different uses. Peak model-estimated environmental concentrations resulting from different diazinon uses range from 0.6 to 59.9 μg/L. These estimates are supplemented with analysis of available California surface water monitoring data from U. S. Geological Survey's National Water Quality Assessment (NAWQA) program and the California Department of Pesticide Regulation. The maximum concentration of diazinon reported by NAWQA from 2000-2005 for California surface waters with agricultural watersheds is 1.06 μg/L. This value is an order of magnitude less than the maximum model-estimated environmental concentration, but is within the range of environmental concentrations estimated for different uses. The maximum concentration of diazinon reported by the California Department of Pesticide Regulation surface water database from 2000-2005 (15.5 μg/L) is on the same order of magnitude as the highest peak model-estimated environmental concentration.

To estimate diazinon exposures to terrestrial-phase CRLF, and its potential prey resulting from uses involving diazinon applications, the T-REX model is used. Only foliar applications are modeled, since T-REX is not appropriate for modeling soil applications with incorporation. Therefore, uses of diazinon which involve only soil incorporation, where not considered in the assessment of exposure of the terrestrial-phase CRLF and its habitat to diazinon since exposure is considered *deminimus*. To further characterize exposures of terrestrial-phase CRLF to dietary and dose-based exposures of diazinon resulting from foliar applications, T-HERPS is used. AgDRIFT and AGDISP are also used to estimate deposition of diazinon on terrestrial habitats from spray drift.

To estimate diazinon exposures to terrestrial-phase habitat, including plants inhabiting semi-aquatic and dry areas, resulting from uses involving diazinon applications, the TerrPlant model is used.

The assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. Direct effects to the CRLF in the aquatic habitat are based on toxicity information for freshwater fish, which are generally used as a surrogate for aquatic-phase amphibians. In the terrestrial habitat, direct effects are based on toxicity information for birds, which are used as a surrogate for terrestrial-phase amphibians. Given that the CRLF's prey items and designated critical habitat requirements in the aquatic habitat are dependant on the availability of freshwater aquatic invertebrates and aquatic plants, toxicity information for these taxonomic groups is also discussed. In the terrestrial habitat, indirect effects due to depletion of prey are assessed by considering effects to terrestrial insects, small terrestrial mammals and frogs. Indirect effects due to modification of the terrestrial habitat are characterized by available data for terrestrial monocots and dicots.

Degradates of diazinon include oxypyrimidine and diazoxon. Comparison of available toxicity information for oxypyrimidine indicates lesser aquatic toxicity than the parent for freshwater and estuarine/marine fish, invertebrates, aquatic plants and birds. Because oxypyrimidine is not of greater toxicological concern compared to diazinon, concentrations of this degradate are not assessed further. Available data indicate that diazoxon is more toxic to amphibians than the parent compound. Also, diazoxon is at least as toxic as the parent to birds. Submitted environmental fate studies for diazinon do not identify diazoxon, as it does not form >10% of residues, indicating that it is not expected to be a major degradate of diazinon in aquatic and terrestrial environments. However, diazoxon has been detected in precipitation samples in California, indicating that it is formed in the atmosphere; therefore, resulting in the potential for atmospheric deposition of diazoxon to aquatic and terrestrial habitats of the CRLF. As discussed above, adequate tools are unavailable at this time to quantify exposures through atmospheric transport and deposition. Since diazoxon is expected to be transported to CRLF habitats primarily through atmospheric deposition, and there is no tool available for quantifying that exposure, exposures of CRLF, its prey and its habitat to diazoxon are explored qualitatively in this assessment. Therefore, diazinon alone is considered in quantifying exposures of CRLF, its prey and its habitats.

Risk quotients (RQs) are derived as quantitative estimates of potential high-end risk. Acute and chronic RQs are compared to the Agency's levels of concern (LOCs) for Federally-listed threatened species to identify if diazinon use within the action area has any direct or indirect effect on the CRLF. Based on estimated environmental concentrations for the currently registered uses of diazinon, RQ values are above the Agency's LOC for direct acute and chronic effects on the CRLF; this represents a "may affect" determination. RQs exceed the LOC for acute and chronic exposures to aquatic invertebrates and for acute exposures to terrestrial invertebrates. Therefore, there is a potential to indirectly affect juvenile and adult CRLF due to effects to the invertebrate forage base in aquatic and terrestrial habitats. The effects determination for indirect effects to the CRLF due to effects to its prey base is "may affect." When considering the prey of larger CRLF in aquatic and terrestrial habitats (*e.g.* frogs, fish and small mammals), RQs for these taxa also exceed the LOC for acute and chronic exposures, resulting in a "may affect" determination. RQ values for plants in aquatic and terrestrial habitats do not exceed the LOC; therefore, indirect effects to the CRLF through effects on aquatic and terrestrial habitats result in a "no effect" (NE) determination.

All "may affect" determinations are further refined using available evidence to determine whether they are "not likely to adversely affect" (NLAA) or "likely to adversely affect" (LAA). Additional evidence includes available monitoring data, likelihood of individual mortality analysis and consideration of species sensitivity distributions. Risk conclusions and effects determinations for the CRLF based on direct and indirect effects are summarized in **Table 1a**. Use-specific determinations based on indirect effects due to effects to prey in aquatic and terrestrial habitats are defined in **Table 1b**. Determinations for effects to critical habitat are summarized in **Table 1c**. The determination for direct effects to the CRLF in aquatic and terrestrial habitats is LAA. For indirect effects to the CRLF due to potential acute and chronic or chronic effects to prey, the determination is LAA.

Although the risk of direct acute effects to both aquatic- and terrestrial-phase amphibians relied on the use of surrogate species' data, toxicity data are available for both aquatic-and terrestrial-phase amphibians. These data suggest that amphibians are considerably less sensitive to diazinon than either the fish or birds used as surrogates for aquatic- and terrestrial-phase amphibians, respectively. Had these data been used to calculate acute risk quotients, none of the uses evaluated would have exceeded acute risk LOCs for direct effects to the CRLF; however, the data were not of sufficient quality to use quantitatively. To the extent that the aquatic- and terrestrial-phase CRLF are less sensitive than the surrogate species, this assessment may be overly conservative.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated to seek concurrence with the LAA determinations and to determine whether there are reasonable and prudent alternatives and/or measures to reduce and/or eliminate potential incidental take.

Table 1.a Diazinon Effects Determination Summary for the CRLF.

Assessment Endpoint	Exposure (duration, habitat)	Effects Determination[1]	Basis for Determination
Direct effects to CRLF	Acute, aquatic	LAA[2]	- Acute LOC is exceeded for most uses (all but fig, blueberries, and caneberries) based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data. - At the highest estimated concentration of diazinon in water (resulting from use on lettuce), the likelihood of individual mortality is 1 in 5. - Maximum observed concentrations of diazinon in surface waters are sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic vertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to ≤55% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all but 1 use (fig) based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses (almonds, blueberries, caneberries, fig, lettuce, melons, outdoor ornamentals, strawberries and tree fruit); based on the most sensitive surrogate bird data. - Refined estimates of exposure based on CRLF-specific diet considerations result in LOC exceedances for dose-based and dietary-based exposures.
	Chronic, terrestrial	LAA	- Chronic LOC is exceeded for all foliar uses based on the most sensitive surrogate bird data. - Refined estimates of exposure based on CRLF-specific diet considerations result in LOC exceedances for dietary-based exposures.
Indirect effects to tadpole CRLF via reduction of prey (*i.e.*, algae)	Aquatic	NE	- LOC is not exceeded for any uses of diazinon.
Indirect effects to juvenile and adult CRLF via reduction of prey (*i.e.*, invertebrates)	Acute, aquatic	LAA	- Acute LOC is exceeded for all uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate invertebrate data. - Estimated concentrations of diazinon in water resulting from all uses result in a likelihood of individual mortality of 100%. - Of the NAWQA monitoring data from California surface waters with agricultural watersheds, 51% of samples contained concentrations of diazinon that were sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic invertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to >70% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate invertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses based on the most sensitive surrogate terrestrial invertebrate data.

Indirect effects to adult CRLF via reduction of prey (*i.e.*, fish, frogs, mice)	Acute, aquatic	LAA	- Acute LOC is exceeded for several uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data. - At the highest estimated concentration of diazinon in water (resulting from use on lettuce), the likelihood of individual mortality is 1 in 5. - Maximum observed concentrations of diazinon in surface waters are sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic vertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to ≤55% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all but 1 use based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses based on the most sensitive surrogate amphibian data. - Refined estimates of exposure based on amphibian-specific diet considerations result in LOC exceedances for dietary-based and dose-based exposures. - For foliar uses, effects determination based on acute effects to mice is NLAA.
	Chronic, terrestrial	LAA	- Chronic LOC is exceeded for all foliar uses based on the most sensitive surrogate mammalian and amphibian data. - Refined estimates of exposure based on amphibian-specific diet considerations result in LOC exceedances for dietary-based exposures.
Indirect effects to CRLF via reduction of habitat and/or primary productivity (*i.e.*, plants)	Aquatic	NE	- Diazinon use does not directly affect non-vascular aquatic plants or vascular terrestrial plants. Estimated EECs for all modeled diazinon use scenarios within the action area are well below the threshold concentration for aquatic, non-vascular plants as well as terrestrial plants inhabiting semi-aquatic or terrestrial areas. - Although there are no toxicity data for aquatic vascular plants, the data for nonvascular aquatic plants and vascular terrestrial plants, the lack of any reported field incidents involving plants, and mesocosm data indicating that plants were not affected indicate that plants are less sensitive to diazinon than animals. In addition, plants are not likely to be affected by diazinon's mode of action.
	Terrestrial	NE	

[1]LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect
[2]Although a number of uses exceed the acute risk LOC for listed species, it is possible that for at least some of these uses, the likelihood of individual mortality may be sufficiently low to arrive at a NLAA determination.

Table 1.b. Diazinon use-specific indirect effects determinations[1] based on effects to prey.

Use	Algae	Aquatic Invertebrates		Terrestrial Invertebrates (Acute)	Aquatic phase frogs and fish		Terrestrial-phase frogs		Small Mammals	
		Acute	Chronic		Acute	Chronic	Acute	Chronic	Acute	Chronic
Almonds	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Blueberries	NE	LAA	LAA	LAA	NE	LAA	LAA	LAA	NLAA	LAA
Cole crops	NE	LAA	LAA	NE	NE	LAA	NE	NE	NE	NE
Cranberries	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Fig	NE	LAA	LAA	LAA	NE	NE	LAA	LAA	NLAA	LAA
Leafy vegetables	NE	LAA	LAA	NE	LAA	LAA	NE	NE	NE	NE
lettuce	NE	LAA	LAA	LAA	LAA	LAA	LAA	LAA	NLAA	LAA
Melons	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
outdoor ornamentals	NE	LAA	LAA	LAA	LAA	LAA	LAA	LAA	NLAA	LAA
Root crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
Row crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
strawberries	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
tomatoes	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
Tree fruit	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Tuber crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE

[1]LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect

Table 1.c Effects Determination Summary for the Critical Habitat Impact Analysis

Assessment Endpoint	Effects Determination	Basis
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	No effect	Risk of diazinon to plants assumed to be negligible based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident.
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source. [1]	No effect	Risk of diazinon to plants assumed to be negligible based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Habitat modification	RQs exceeded for acute and chronic effects to prey items (invertebrates, fish, aquatic phase amphibians)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.*, algae)	No effect	No RQs for algae are exceeded
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	No effect	Based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident. Also, no RQs are exceeded for terrestrial plants exposed to diazinon.
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	No effect	Based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident. Also, no RQs are exceeded for terrestrial plants exposed to diazinon.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Habitat modification	Diazinon poses acute and chronic risk to prey items of the CRLF (terrestrial invertebrates, mice, terrestrial-phase frogs).
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Habitat modification	Diazinon poses acute and chronic risk to prey items of the CRLF (terrestrial invertebrates, mice, terrestrial-phase frogs).

[1] Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (*i.e.*, food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (*i.e.*, attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the species.
- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual frogs and potential adverse modification to critical habitat.

2. Problem Formulation

Problem formulation provides a strategic framework for the risk assessment. By identifying the important components of the problem, it focuses the assessment on the most relevant life history stages, habitat components, chemical properties, exposure routes, and endpoints. The structure of this risk assessment is based on guidance contained in U.S. EPA's *Guidance for Ecological Risk Assessment* (U.S. EPA 1998) and is consistent with procedures and methodology outlined in the Overview Document (U.S. EPA 2004) and reviewed by the U.S. Fish and Wildlife Service and National Marine Fisheries Service (USFWS/NMFS 2004).

2.1. Purpose

The purpose of this endangered species assessment is to evaluate potential direct and indirect effects on individuals of the federally threatened California red-legged frog *(Rana aurora draytonii*) (CRLF) arising from FIFRA regulatory actions regarding use of diazinon on several agricultural uses on fruit, nuts and vegetables and non-agricultural uses on outdoor ornamental crops. In addition, this assessment evaluates whether these actions can be expected to result in the destruction or adverse modification of the species' critical habitat. Key biological information for the CRLF is included in Section 2.5, and designated critical habitat information for the species is provided in Section 2.6 of this assessment. This ecological risk assessment has been prepared as part of the *Center for Biological Diversity (CBD) vs. EPA et al*. (Case No. 02-1580-JSW(JL)) settlement entered in the Federal District Court for the Northern District of California on October 20, 2006.

In this endangered species assessment, direct and indirect effects to the CRLF and potential adverse modification to its critical habitat are evaluated in accordance with the methods (both screening level and species-specific refinements, when appropriate) described in the Agency's Overview Document (U.S. EPA 2004).

In accordance with the Overview Document, provisions of the ESA, and the Services' *Endangered Species Consultation Handbook,* the assessment of effects associated with registrations of diazinon are based on an action area. The action area is considered to be the area directly or indirectly affected by the federal action, as indicated by the exceedance of Agency Levels of Concern (LOCs) used to evaluate direct or indirect effects. It is acknowledged that the action area for a national-level FIFRA regulatory decision associated with a use of diazinon may potentially involve numerous areas throughout the United States and its Territories. However, for the purposes of this assessment, attention will be focused on relevant sections of the action area including those geographic areas associated with locations of the CRLF and its designated critical habitat within the state of California.

As part of the "effects determination," one of the following three conclusions will be reached regarding the potential for registration of diazinon at the use sites described in this document to affect CRLF individuals and/or result in the destruction or adverse modification of designated CRLF critical habitat:

- "No effect";
- "May affect, but not likely to adversely affect"; or
- "May affect and likely to adversely affect".

Critical habitat identifies specific areas that have the physical and biological features, known as primary constituent elements (PCEs) essential to the conservation of the listed species. The PCEs for CRLFs are aquatic and upland areas where suitable breeding and non-breeding aquatic habitat is located, interspersed with upland foraging and dispersal habitat (Section 2.6).

If the results of initial screening-level assessment methods show no direct or indirect effects (no LOC exceedances) upon individual CRLFs or upon the PCEs of the species' designated critical habitat, a "no effect" determination is made for the FIFRA regulatory action regarding diazinon as it relates to this species and its designated critical habitat. If, however, direct or indirect effects to individual CRLFs are anticipated and/or effects may impact the PCEs of the CRLF's designated critical habitat, a preliminary "may affect" determination is made for the FIFRA regulatory action regarding diazinon.

If a determination is made that use of diazinon within the action area(s) associated with the CRLF "may affect" this species and/or its designated critical habitat, additional information is considered to refine the potential for exposure and for effects to the CRLF and other taxonomic groups upon which these species depend (e.g., aquatic and terrestrial vertebrates and invertebrates, aquatic plants, riparian vegetation, etc.). Additional information, including spatial analysis (to determine the geographical proximity of CRLF habitat and diazinon use sites) and further evaluation of the potential impact of diazinon on the PCEs is also used to determine whether destruction or adverse modification to designated critical habitat may occur. Based on the refined information, the Agency uses the best available information to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that "may affect and are likely to adversely affect" the CRLF and/or the PCEs of its designated critical habitat. This information is presented as part of the Risk Characterization in Section 5 of this document.

The Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because diazinon is expected to directly impact living organisms within the action area (defined in Section 2.7), critical habitat analysis for diazinon is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes (i.e., the biological resource requirements for the listed species associated with the critical habitat or important physical aspects of the habitat that may be reasonably influenced through biological processes). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and appreciably diminish the value of the habitat. Evaluation of actions related to use of diazinon that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. Actions that may affect the CRLF's designated critical habitat have been identified by the Services and are discussed further in Section 2.6.

2.2. Scope

Diazinon was once one of the most widely used insecticides in the U. S. for household as well as agricultural pest control. However, a December 2000 agreement with the technical registrants phased out and cancelled all indoor and outdoor residential uses of diazinon by 2005. Additionally, all registrations for granular products, except use on lettuce in California and Arizona and two current Section 24c registrations for control of cranberry girdler in the Pacific Northwest were cancelled by 2005. Many mitigation measures that were identified in the 2002 IRED have been implemented, including deletion of aerial applications for all uses except on lettuce, cancellation of all seed treatment uses, and cancellation of foliar applications to all vegetable crops except honeydew melons in California to control leafhoppers. For most uses, only one application per growing season is allowed. Crops with dormant-season and in-season uses, *e.g.* stone fruits, are limited to a single application per season, for a total of two applications per year. Section 3 registrations on succulent beans, succulent peas, peppers, potatoes, and squash were cancelled by August 2004; watercress was phased out in all states but Hawaii by 2006. Currently, applications to fruit, nut, vegetable and outdoor ornamental crops are allowed.

The end result of the EPA pesticide registration process (the FIFRA regulatory action) is an approved product label. The label is a legal document that stipulates how and where a given pesticide may be used. Product labels (also known as end-use labels) describe the formulation type (e.g., liquid or granular), acceptable methods of application, approved use sites, and any restrictions on how applications may be conducted. Thus, the use or potential use of diazinon in accordance with the approved product labels for California is "the action" being assessed.

Although current registrations of diazinon allow for use nationwide, this ecological risk assessment and effects determination addresses currently registered uses of diazinon in portions of the action area that are reasonably assumed to be biologically relevant to the CRLF and its designated critical habitat. Further discussion of the action area for the CRLF and its critical habitat is provided in Sections 2.7 and 5.2.4.

This assessment quantitatively considers effects of exposures of diazinon only. Diazinon degrades into two notable degradates: oxypyrimidine and diazoxon. Oxypyrimidine is the primary degradate of diazinon and is seen in both the laboratory studies and field studies. Diazoxon, an intermediate degradate which degrades further to oxypyrimidine, was detected in field dissipation studies, but was not reported to be a major degradate in laboratory studies. In monitoring studies in California, diazoxon has been detected in air and precipitation samples. Comparison of available toxicity information for the degradates of diazinon indicates that oxypyrimidine is practically nontoxic to aquatic (fish and invertebrates) and terrestrial animals (birds) on an acute exposure basis and it is practically nontoxic to terrestrial animals (birds) on a subacute dietary exposure basis.

Diazoxon, a relatively short-lived degradate, has greater toxicity compared to that of the parent. Diazoxon is very highly toxic to birds on an acute oral exposure basis and is highly toxic to birds on a subacute dietary exposure basis. Acceptable acute toxicity data for diazoxon are not available for aquatic animals. A detailed summary of the available ecotoxicity information for the diazinon degradates is presented in **Appendix A**.

As summarized in **Appendix L**, there are no product LD_{50} values, with associated 95% Confidence Intervals (CIs) available. As discussed in U.S. EPA (2000b), a quantitative component-based evaluation of mixture toxicity requires data of appropriate quality for each component of a mixture. In this mixture evaluation, an LD_{50} with associated 95% confidence interval is needed for the formulated product. The same quality of data is also required for each component of the mixture. Given that the formulated products for diazinon do not have LD_{50} data available, it is not possible to undertake a quantitative or qualitative analysis for potential interactive effects. However, because the active ingredients are not expected to have similar mechanisms of action, metabolites, or toxicokinetic behavior, it is reasonable to conclude that an assumption of dose-addition would be inappropriate. Consequently, an assessment based on the toxicity of diazinon is the only reasonable approach that employs the available data to address the potential acute risks of the formulated products in **Appendix L**.

This assessment considers only the single active ingredient of diazinon. However, the assessed species and their environments may be exposed to multiple pesticides simultaneously. Interactions of other toxic agents with diazinon could result in additive effects, synergistic effects or antagonistic effects. Evaluation of pesticide mixtures is beyond the scope of this assessment because of the myriad factors that cannot be quantified based on the available data. Those factors include identification of other possible co-contaminants and their concentrations, differences in the pattern and duration of exposure among contaminants, and the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Evaluation of factors that could influence additivity/synergism is beyond the scope of this assessment and is beyond the capabilities of the available data to allow for an evaluation. However, it is acknowledged that not considering mixtures could over- or under-estimate risks depending on the type of interaction and factors discussed above.

2.3. Previous Assessments

2.3.1. Diazinon IRED

The Agency completed a screening-level ecological risk assessment for diazinon use in February 2000 (U.S. EPA 2002). This assessment was based on laboratory ecotoxicological data submitted by the registrant in support of reregistration and from data in publicly available literature, a substantial amount of monitoring data for freshwater streams, lakes, reservoirs, and estuarine areas, and incident reports of adverse effects on aquatic and terrestrial organisms associated with the use of diazinon. The results of the Agency's ecological assessments for diazinon are fully discussed in the July 31, 2006, final Interim Reregistration Eligibility Decision (IRED) (U.S. EPA 2006).

2.3.2. Barton Springs Salamander Endangered Species Assessment

The Agency has recently completed an ecological risk assessment evaluating the potential effects of diazinon on the endangered Barton Springs salamander (*Eurycea sosorum*). The assessment was a component of the settlement of the court case "*Center for Biological Diversity and Save Our Springs Alliance v. Leavitt, No. 1:04CV00126-CKK"*. Conclusions regarding diazinon use in its action area were: it would have no direct acute effect on the salamander; diazinon use would not likely adversely affect the salamander through direct chronic effects; that diazinon was not likely to adversely affect the salamander through effects on it prey; that diazinon use would have no effect on the salamander's habitat.

2.3.3. Aquatic Life Criteria

The Clean Water Act requires the EPA to publish water quality criteria that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare which might be expected from the presence of pollutants in any body of water, including ground water. An Aquatic Life Ambient Water Quality Criteria document was published for diazinon in 2005 (USEPA 2005). The recommendation of the document in regards to freshwater aquatic life includes the following: "Freshwater aquatic life should not be affected if the one-hour average concentration of diazinon does not exceed 0.17 micrograms per liter more than once every three years on the average (acute criterion) and if the four-day average concentration of diazinon does not exceed 0.17 micrograms per liter more than once every three years on the average (chronic criterion)." While these recommended criteria do not, in themselves, impose any requirements, states and authorized tribes can use them to develop water quality standards.

2.4. Stressor Source and Distribution

2.4.1. Environmental Fate and Transport Assessment

The following fate and transport description for diazinon is consistent with the information contained in the initial 2002 IRED (U.S. EPA, 2002). Diazinon is mobile and moderately persistent in the environment. As shown in **Table 2**, it degrades by microbial metabolism as well as the abiotic processes of hydrolysis and photolysis. Aerobic soil metabolism half-lives were 37 and 38 days in two laboratory studies. No acceptable anaerobic microbial metabolism data were submitted. Hydrolysis half-lives were 12, 138 and 77 days at pH's 5, 7 and 9, respectively. Photolysis occurred with half-lives of 17 to 37 hours on soil and 37 days in aqueous solution. The dominant degradation process is expected to depend on environmental conditions.

Table 2. General chemical and environmental fate properties of diazinon.

Chemical/Fate Parameter	Value	Source
Molecular mass	304.3 g/mol	Product chemistry
Vapor pressure (20°C)	1.40×10^{-4} torr	U.S. EPA, 1988
Henry's Law Constant	1.40×10^{-6} atm-m^3/mol	U.S. EPA, 1988
Water solubility (20°C)	40 mg/L	U.S. EPA, 1988
Octanol-to-water partition coefficient (K_{OW})	2.5×10^4	U.S. EPA, 1988
Freundlich soil-to-water partition coefficients (K_f) for adsorption (soil type)	5.6 (1/n = 0.63) (sand) 113.5 (1/n = 0.70) (unclassified) 11.7 (1/n = 0.77) (loam) 3.7 (1/n = 0.60) (sand) 4.5 (1/n = 0.55) (loamy sand) 23.4 (1/n = 0.93) (sandy clay loam)	MRID 00118032
Organic carbon normalized partition coefficients (K_{OC})[1]	439, 485, 560, 638, 720, 854 L/kg$_{OC}$	MRID 00118032
Hydrolysis half-lives (23-25°C)	12 d (pH 5) 138 d (pH 7) 77 d (pH 9)	MRID 40931101
Aqueous photolysis half-life	37 days	MRID 40863401
Soil photolysis half-life	17.3 hrs 37.4 hrs	MRID 00153229 MRID 00153230
Aerobic soil metabolism half-lives	37.4 days 38.0 days	MRID 40028701 MRID 44746001
Fish bioconcentration	542x (edible) 583x (viscera) 542x (whole fish)	MRID 40660808

[1] K_{OC} values were calculated based on K_f values for adsorption (*e.g.*, $K_{OC} = K_f$ (adsorption) ÷ fraction organic carbon).

Diazinon is relatively mobile in soil, as Freundlich partition coefficients estimated from batch equilibrium studies ranged from 3.7 (1/n=0.60) to 23.4 (1/n=0.93) in sandy and loamy soils and were 114 (1/n=0.70) in an unclassified soil rich in organic carbon. However, Freundlich exponents were often less than 0.9. Diazinon binding in soil is correlated with organic carbon content, with a K_{oc} range of 439 to 854 L/kg$_{oc}$. Italian researchers reported that in 25 soils tested, retardation factors (R_f) indicate that diazinon was slightly mobile in 80% of soils tested and immobile in 20%. In saturated columns, diazinon was shown to leach in light textured soils with low organic matter (Arienzo *et al.*, 1994). In column leaching studies submitted to the Agency, diazinon residues which had been aged 30 days were shown to be mobile in columns of Lowell sand, Hanford sandy loam, Huntington loam and Armor silty clay soils.

Diazinon does volatilize to some degree, as indicated by detections in air, rain, and fog, as reported by USGS and other researchers and discussed in greater detail below. Field dissipation studies had half-lives ranging from 5 to 20 days, which is consistent with available laboratory data. Studies were done with three different formulations (granular, wettable powder and emulsifiable concentrate) and there were no apparent differences in field dissipation among the three formulation types.

The environmental fate characteristics of diazinon are consistent with those of compounds expected to occur in water resources. There is a considerable amount of evidence showing that diazinon has occurred and continues to occur in both ground and surface water as a result of nonagricultural and agricultural uses.

Diazinon bioconcentrated to over 500x in bluegill tissue. Depuration was rapid with 96% removal after 7 days.

Oxypyrimidine (2-isopropy-6-methyl-4-pyrimidinol) is the primary degradate of diazinon and is seen in both the laboratory studies and field studies. While quantitative kinetic estimates of oxypyrimidine are not available, it appears to be more persistent than diazinon. In a soil column leaching study, oxypyrimidine was the most mobile residue and occurred as 39% to 53% of the applied in the leachate.

Diazoxon (O,O-diethyl-O-(2-isopropyl-4-methyl-6-pyrimidinyl)phosphonate), an intermediate degradate formed by hydrolysis, retains the organophosphate moiety of the parent compound and is a stronger cholinesterase inhibitor than parent diazinon. Diazoxon hydrolyzes rapidly to oxypyrimidine under most circumstances. Diazoxon was detected in field dissipation studies, but was not reported to be a major degradate in laboratory studies. Diazoxon has also been reported in air, rain, fog and surface waters. The persistence of diazoxon in the atmosphere and in precipitation is unknown.

Potential transport mechanisms of diazinon include pesticide surface water runoff, spray drift, and secondary drift of volatilized or soil-bound residues leading to deposition onto nearby or more distant ecosystems. The magnitude of pesticide transport via secondary drift depends on the pesticide's ability to be mobilized into air and its eventual removal through wet and dry deposition of gases/particles and photochemical reactions in the atmosphere. Significant masses of diazinon have been measured volatilizing off of treated fields (Majewski *et al.* 1990).

A number of studies have documented atmospheric transport and deposition of pesticides from the Central Valley to the Sierra Nevada Mountains (Fellers *et al*., 2004, Sparling *et al*., 2001, LeNoir *et al*., 1999, and McConnell et al., 1998). Prevailing winds blow across the Central Valley eastward to the Sierra Nevada Mountains, transporting airborne industrial and agricultural pollutants into Sierra Nevada ecosystems (Fellers *et al*., 2004, LeNoir *et al*., 1999, and McConnell *et al*., 1998). Therefore, physicochemical properties of the pesticide that describe its potential to enter the air from water or soil (*e.g*., Henry's Law constant and vapor pressure), pesticide use, modeled estimated concentrations in water and air, and available air monitoring data from the Central Valley and the Sierra Nevada Mountains are considered in qualitatively evaluating the potential for atmospheric transport of diazinon to habitat for the CRLF.

At this time, EFED does not have an approved model for estimating atmospheric transport of pesticides and resulting exposure to aquatic organisms in areas receiving pesticide deposition from the atmosphere. Potential mechanisms of transport of diazinon to the atmosphere, such as volatilization, wind erosion of soil, and spray drift, can only be discussed qualitatively. The extent to which diazinon will be deposited from the air to the action area is unknown. The possible concentrations resulting from wet deposition are qualitatively explored.

2.4.2. Mechanism of Action

Organophosphate toxicity is based on the inhibition of the enzyme acetylcholinesterase which cleaves the neurotransmitter acetylcholine. Inhibition of acetylcholinesterase by organophosphate insecticides, such as diazinon, interferes with proper neurotransmission in cholinergic synapses and neuromuscular junctions (USEPA 2002).

2.4.3. Use Characterization

Nationally, diazinon usage has substantially declined since 2004. The pesticide is used to control foliage and soil insects and pests of many fruit, nut, vegetable, and ornamental crops as well as insect pests of cattle. All residential uses have been cancelled. Approximately 4 million pounds of the active ingredient diazinon are used annually on agricultural sights. **Figure 1** presents the national distribution of annual diazinon agricultural use estimated between 1995 and 1998 (USGS 2007). This historical information is based on estimates that include uses that have been restricted. Therefore, there has likely been a significant reduction in both the amount and distribution of diazinon use. From 2002-2005, the percentage of total diazinon use in California was highest on lettuce (29% of total use), structural pest control (11.4%), almonds (9.0), prunes (5.6%), peaches (5.4 %), spinach (4.6%), broccoli (4.0 %) and onion (3.4 %) (CDPR 2007a).

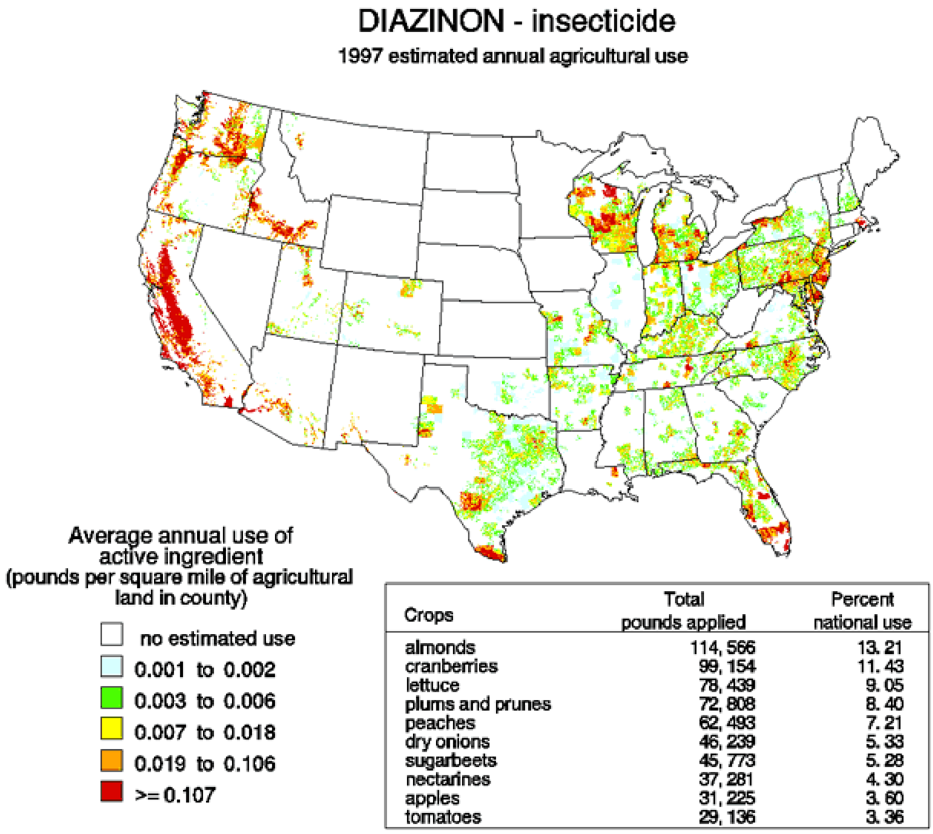


Figure 1. Historical (1997) Extent of Diazinon Use (lbs)

Analysis of labeled use information is the critical first step in evaluating the federal action. The current label for diazinon represents the FIFRA regulatory action; therefore, labeled use and application rates specified on the label form the basis of this assessment. The assessment of use information is critical to the development of the action area and selection of appropriate modeling scenarios and inputs.

Currently, labeled uses of diazinon include several fruit, nut, and vegetable crops as well as cattle ear tags. There are 14 active Section 3 labels of products containing diazinon. The EPA registration numbers for these labels are 2935-408, 4581-392, 5905-248, 19713-91, 19713-492, 66222-9, 66222-10, 66222-103, 11556-123, 39039-3, 39039-6, 61483-78, 61483-80, and 61483-92. In addition, there are 3 special local needs (Section 24c) labels for California: CA-000030, CA-030014 and CA-050002 (**Appendix J**). A comprehensive list of these uses, along with the methods and rates associated with applications of diazinon is included in **Table 3**. In this assessment, crops are grouped based on similar forms and application practices. These groups and the specific crops associated with these groups are defined in **Table 3.**

Table 3. Methods and rates of application of currently registered uses of diazinon.

Uses	Application type**	Number of applications/ year	Maximum rate / application (lbs a.i./A)
Almonds	dormant or foliar	1	3
Blueberries	foliar	1	1
	fire ant	1	1
Caneberries	foliar	1	2
Cole crops[1]	soil incorporation	1	4
Fig	foliar	1	0.5
Leafy vegetables[2]	soil incorporation	1	4
Lettuce	soil incorporation	1*	2
	foliar	1*	2
Melons [3]	soil incorporation	1	4
	foliar	1	4
outdoor ornamentals	foliar	1*	1
Root crops [4]	soil incorporation	1	4
Row crops [5]	soil incorporation	1	4
Strawberries	soil incorporation	1	1
	foliar	1	1
Tomatoes	soil incorporation	1	4
Tree fruit [6]	1 foliar + 1 dormant	2	2
Tuber crops [7]	soil incorporation	1	4

*Labels indicate a maximum number of applications per crop. Therefore, if there are multiple crops per year, there is potential for more than 1 application per year.

**Aerial applications are permitted for uses on lettuce only. Therefore, all other applications are made by ground methods.

[1] Specifically: broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens

[2] Specifically: spinach, endive

[3] Specifically: cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons

[4] Specifically: onion, radishes

[5] Specifically: carrots, beans, peppers (bell and chili), peas (succulent), beets (red)

[6] Specifically: apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes

[7] Specifically: rutabagas, sweet potatoes

The special local needs (SLN) label CA-05000200 is registered to the California Department of Food and Agriculture, to be used for fruit fly pests subject to State quarantine action on ornamental tree fruit nursery stock (all fruit must be removed from plants) and ornamental nursery stock. This SLN is for soil drench under host plants. Treatments are for quarantine and eradication purposes and are limited to conduct under direct supervision by federal, state or county authorized persons. This SLN is generally used at large nurseries in southern California to treat fruit fly infestations. This treatment is not used every year, and is generally used as a last resort. The SLN is labeled for 3 applications at 14 day intervals at a maximum rate of 5 lbs a.i./A per application. Although this SLN label represents the highest application rate for ornamental use, it is not considered in deriving EECs and RQs to represent ornamental use in this assessment, given its limited and sporadic use. However, EECs and RQs are discussed in the risk characterization section of this document.

Labels also permit applications of diazinon to ginseng, cranberry and pineapple (which are not included in **Table 3**); however, based on analysis of National Agricultural Statistics Service (NASS) data, these crops are not grown in California and are therefore, not relevant to this assessment.

Pesticide use data available from the California Department of Pesticide Regulation (CDPR 2007a), includes county-level data for various diazinon uses from 2002-2005. Past uses of diazinon include all of the uses identified in **Table 3**, as well as uses that are no longer permitted. Analysis of the mass of diazinon applied with consideration of the application area indicates that applications have been made at or above the maximum application rates identified in **Table 3**. In situations were the use data indicate higher than maximum label application rates, the discrepancy is considered to be most likely due to misreporting.

There is potential use of diazinon contained in cattle ear tags within the California. Ear tags may contain up to 6 grams of diazinon each (EPA Reg. No. 61483-80). However, most of the diazinon released from cattle ear tags is expected to volatilize, adsorb to the cow or to soil, or degrade. However, given that this particular formulation of diazinon is not subject to extensive transport, exposure is expected to be *deminimus*; therefore, this exposure route was not quantitatively assessed for potential risk to the CRLF.

2.5. Assessed Species

The CRLF was listed as a threatened species by USFWS effective June 24, 1996 (USFWS 1996). It is one of two subspecies of the red-legged frog and is the largest native frog in the western United States (USFWS 2002). A brief summary of information regarding CRLF distribution, reproduction, diet, and habitat requirements is provided in Sections 2.5.1 through 2.5.4, respectively. Further information on the status, distribution, and life history of and specific threats to the CRLF is provided in **Attachment 1**.

Final critical habitat for the CRLF was designated by USFWS on April 13, 2006 (USFWS 2006; 71 FR 19244-19346). Further information on designated critical habitat for the CRLF is provided in Section 2.6.

2.5.1. Distribution

The CRLF is endemic to California and Baja California (Mexico) and historically inhabited 46 counties in California including the Central Valley and both coastal and interior mountain ranges (USFWS 1996). Its range has been reduced by about 70%, and the species currently resides in 22 counties in California (USFWS 1996). The species has an elevation range of near sea level to 1,500 meters (5,200 feet) (Jennings and Hayes 1994); however, nearly all of the known CRLF populations have been documented below 1,050 meters (3,500 feet) (USFWS 2002).

Populations currently exist along the northern California coast, northern Transverse Ranges (USFWS 2002), foothills of the Sierra Nevada Mountains (5-6 populations), and in southern California south of Santa Barbara (two populations) (Fellers 2005a). Relatively larger numbers of CRLFs are located between Marin and Santa Barbara counties (Jennings and Hayes 1994). A total of 243 streams or drainages are believed to be currently occupied by the species, with the greatest numbers in Monterey, San Luis Obispo, and Santa Barbara counties (USFWS 1996). Occupied drainages or watersheds include all bodies of water that support CRLFs (*i.e.*, streams, creeks, tributaries, associated natural and artificial ponds, and adjacent drainages), and habitats through which CRLFs can move (i.e., riparian vegetation, uplands) (USFWS 2002).

The distribution of CRLFs within California is addressed in this assessment using four categories of location including recovery units, core areas, designated critical habitat, and known occurrences of the CRLF reported in the California Natural Diversity Database (CNDDB) that are not included within core areas and/or designated critical habitat (see **Figure 2**); Recovery units, core areas, and other known occurrences of the CRLF from the CNDDB are described in further detail in this section, and designated critical habitat is addressed in Section 2.6. Recovery units are large areas defined at the watershed level that have similar conservation needs and management strategies. The recovery unit is primarily an administrative designation, and land area within the recovery unit boundary is not exclusively CRLF habitat. Core areas are smaller areas within the recovery units that comprise portions of the species' historic and current range and have been determined by USFWS to be important in the preservation of the species. Designated critical habitat is generally contained within the core areas, although a number of critical habitat units are outside the boundaries of core areas, but within the boundaries of the recovery units. Additional information on CRLF occurrences from the CNDDB is used to cover the current range of the species not included in core areas and/or designated critical habitat, but within the recovery units.

2.5.1.1. Recovery Units

Eight recovery units have been established by USFWS for the CRLF. These areas are considered essential to the recovery of the species, and the status of the CRLF "may be considered within the smaller scale of the recovery units, as opposed to the statewide range" (USFWS 2002). Recovery units reflect areas with similar conservation needs and population statuses, and therefore, similar recovery goals. The eight units described for the CRLF are delineated by watershed boundaries defined by US Geological Survey hydrologic units and are limited to the elevation maximum for the species of 1,500 m above sea level. The eight recovery units for the CRLF are listed in **Table 4** and shown in **Figure 2**.

2.5.1.2. Core Areas

USFWS has designated 35 core areas across the eight recovery units to focus their recovery efforts for the CRLF (see **Figure 2**). **Table 4** summarizes the geographical relationship among recovery units, core areas, and designated critical habitat. The core areas, which are distributed throughout portions of the historic and current range of the species, represent areas that allow for long-term viability of existing populations and reestablishment of populations within historic range. These areas were selected because they: 1) contain existing viable populations; or 2) they contribute to the connectivity of other habitat areas (USFWS 2002). Core area protection and enhancement are vital for maintenance and expansion of the CRLF's distribution and population throughout its range.

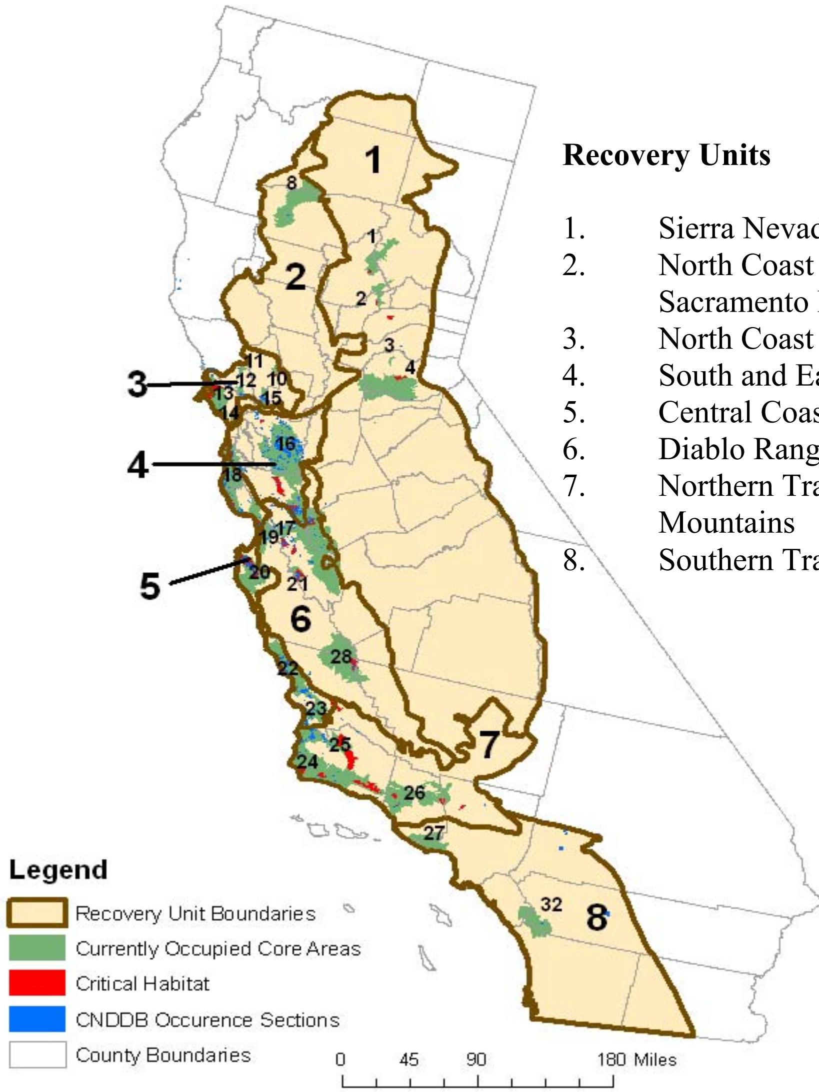
For purposes of this assessment, designated critical habitat, currently occupied (post-1985) core areas, and additional known occurrences of the CRLF from the CNDDB are considered. Each type of location information is evaluated within the broader context of recovery units. For example, if no labeled uses of diazinon occur (or if labeled uses occur at predicted exposures less than the Agency's LOCs) within an entire recovery unit, a "no effect" determination would be made for all designated critical habitat, currently occupied core areas, and other known CNDDB occurrences within that recovery unit. Historically occupied sections of the core areas are not evaluated as part of this assessment because the USFWS Recovery Plan (USFWS 2002) indicates that CRLFs are extirpated from these areas. A summary of currently and historically occupied core areas is provided in **Table 4** (currently occupied core areas are bolded). While core areas are considered essential for recovery of the CRLF, core areas are not federally-designated critical habitat, although designated critical habitat is generally contained within these core recovery areas. It should be noted, however, that several critical habitat units are located outside of the core areas, but within the recovery units. The focus of this assessment is currently occupied core areas, designated critical habitat, and other known CNDDB CRLF occurrences within the recovery units. Federally-designated critical habitat for the CRLF is further explained in Section 2.6.

Table 4. CRLF Recovery Units with Overlapping Core Areas and Designated Critical Habitat.

Recovery Unit [1] (Figure 2)	Core Areas [2,7] (Figure 2)	Critical Habitat Units [3]	Currently Occupied (post-1985) [4]	Historically Occupied [4]
Sierra Nevada Foothills and Central Valley (1) (eastern boundary is the 1,500m elevation line)	**Feather River (1)**	BUT-1A-B	✓	
	Yuba River-S. Fork Feather River (2)	YUB-1		
	--	NEV-1	✓[6]	
	Traverse Creek/Middle Fork American River/Rubicon (3)	--	✓	
	Consumnes River (4)	ELD-1	✓	
	S. Fork Calaveras River (5)	--		✓
	Tuolumne River (6)	--		✓
	Piney Creek (7)	--		✓
	East San Francisco Bay (partial)(16)	--	✓	
North Coast Range Foothills and Western Sacramento River Valley (2)	**Cottonwood Creek (8)**	--	✓	
	Putah Creek-Cache Creek (9)	--		✓
North Coast and North San Francisco Bay (3)	Putah Creek-Cache Creek (partial) (9)	--		✓
	Lake Berryessa Tributaries (10)	NAP-1	✓	
	Upper Sonoma Creek (11)	--	✓	

	Petaluma Creek-Sonoma Creek (12)	--	✓	
	Pt. Reyes Peninsula (13)	MRN-1, MRN-2	✓	
	Belvedere Lagoon (14)	--	✓	
	Jameson Canyon-Lower Napa River (15)	SOL-1	✓	
South and East San Francisco Bay (4)	--	CCS-1A	✓[6]	
	East San Francisco Bay (partial) (16)	ALA-1A, ALA-1B, STC-1B	✓	
	--	STC-1A	✓[6]	
	South San Francisco Bay (partial) (18)	SNM-1A	✓	
Central Coast (5)	**South San Francisco Bay (partial) (18)**	SNM-1A, SNM-2C, SCZ-1	✓	
	Watsonville Slough- Elkhorn Slough (partial) (19)	SCZ-2 [5], MNT-1 [5]	✓	
	Carmel River-Santa Lucia (20)	MNT-2	✓	
	Estero Bay (22)	--	✓	
	Arroyo Grande Creek (23)	SLO-8	✓	
	Santa Maria River-Santa Ynez River (24)	--	✓	
Diablo Range and Salinas Valley (6)	**East San Francisco Bay (partial) (16)**	MER-1A-B	✓	
	--	SNB-1, SBB-2	✓[6]	
	Santa Clara Valley (17)	--	✓	
	Watsonville Slough- Elkhorn Slough (partial)(19)	--	✓	
	Carmel River-Santa Lucia (partial)(20)	--	✓	
	Gablan Range (21)	SNB-3	✓	
	Estrella River (28)	SLO-1	✓	
Northern Transverse Ranges and Tehachapi Mountains (7)	--	SLO-8	✓[6]	
	Santa Maria River-Santa Ynez River (24)	STB-4, STB-5, STB-7	✓	
	Sisquoc River (25)	STB-1, STB-3	✓	
	Ventura River-Santa Clara River (26)	VEN-1, VEN-2, VEN-3	✓	
	--	LOS-1	✓[6]	
Southern Transverse and Peninsular Ranges (8)	**Santa Monica Bay-Ventura Coastal Streams (27)**	--	✓	
	San Gabriel Mountain (29)	--		✓
	Forks of the Mojave (30)	--		✓
	Santa Ana Mountain (31)	--		✓
	Santa Rosa Plateau (32)	--	✓	
	San Luis Rey (33)	--		✓
	Sweetwater (34)	--		✓
	Laguna Mountain (35)	--		✓

[1] Recovery units designated by the USFWS (USFWS 2000, pg 49)
[2] Core areas designated by the USFWS (USFWS 2000, pg 51)
[3] Critical habitat units designated by the USFWS on April 13, 2006 (USFWS 2006, 71 FR 19244-19346)
[4] Currently occupied (post-1985) and historically occupied core areas as designated by the USFWS (USFWS 2002, pg 54)
[5] Critical habitat unit where identified threats specifically included pesticides or agricultural runoff (USFWS
[6] Critical habitat units that are outside of core areas, but within recovery units
[7] Currently occupied core areas that are included in this effects determination are bolded.



Recovery Units

1. Sierra Nevada Foothills and Central Valley
2. North Coast Range Foothills and Western Sacramento River Valley
3. North Coast and North San Francisco Bay
4. South and East San Francisco Bay
5. Central Coast
6. Diablo Range and Salinas Valley
7. Northern Transverse Ranges and Tehachapi Mountains
8. Southern Transverse and Peninsular Ranges

Figure 2. Recovery Unit, Core Area, Critical Habitat, and Occurrence Designations for CRLF

Core Areas:

Feather River
Yuba River- S. Fork Feather River
Traverse Creek/ Middle Fork/ American R. Rubicon
Cosumnes River
South Fork Calaveras River*
Tuolumne River*
Piney Creek*
Cottonwood Creek
Putah Creek – Cache Creek*
Lake Berryessa Tributaries
Upper Sonoma Creek
Petaluma Creek – Sonoma Creek
Pt. Reyes Peninsula
Belvedere Lagoon
Jameson Canyon – Lower Napa River
East San Francisco Bay
Santa Clara Valley
South San Francisco Bay
Watsonville Slough-Elkhorn Slough
Carmel River – Santa Lucia
Gablan Range
Estero Bay
Arroyo Grange River
Santa Maria River – Santa Ynez River
Sisquoc River
Ventura River – Santa Clara River
Santa Monica Bay – Venura Coastal Streams
Estrella River
San Gabriel Mountain*
Forks of the Mojave*
Santa Ana Mountain*
Santa Rosa Plateau
San Luis Ray*
Sweetwater*
Laguna Mountain*

* Core areas that were historically occupied by the California red-legged frog are not included in the map

2.5.1.3. Other Known Occurrences from the CNDBB

The CNDDB provides location and natural history information on species found in California. The CNDDB serves as a repository for historical and current species location sightings. Information regarding known occurrences of CRLFs outside of the currently occupied core areas and designated critical habitat is considered in defining the current range of the CRLF. See: http://www.dfg.ca.gov/bdb/html/cnddb_info.html for additional information on the CNDDB.

2.5.2. Reproduction

CRLFs breed primarily in ponds; however, they may also breed in quiescent streams, marshes, and lagoons (Fellers 2005a). According to the Recovery Plan (USFWS 2002), CRLFs breed from November through late April. Peaks in spawning activity vary geographically; Fellers (2005b) reports peak spawning as early as January in parts of coastal central California. Eggs are fertilized as they are being laid. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984). Egg masses contain approximately 2000 to 6000 eggs ranging in size between 2 and 2.8 mm (Jennings and Hayes 1994). Embryos hatch 10 to 14 days after fertilization (Fellers 2005a) depending on water temperature. Egg predation is reported to be infrequent and most mortality is associated with the larval stage (particularly through predation by fish); however, predation on eggs by newts has also been reported (Rathburn 1998). Tadpoles require 11 to 28 weeks to metamorphose into juveniles (terrestrial-phase), typically between May and September (Jennings and Hayes 1994, USFWS 2002); tadpoles have been observed to over-winter (delay metamorphosis until the following year) (Fellers 2005b, USFWS 2002). Males reach sexual maturity at 2 years, and females reach sexual maturity at 3 years of age; adults have been reported to live 8 to 10 years (USFWS 2002). **Figure 3** depicts CRLF annual reproductive timing.

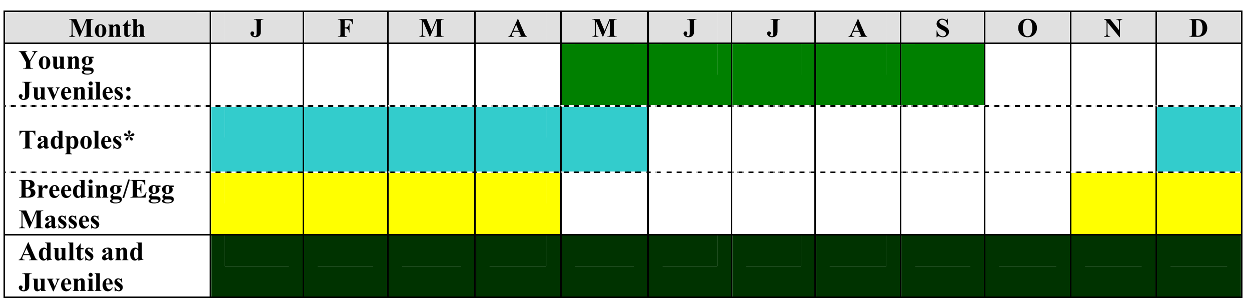


Figure 3. CRLF Reproductive Events by Month *except those that over-winter.

2.5.3. Diet

Although the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically, it is assumed that their diet is similar to that of other frog species, with the aquatic phase feeding exclusively in water and consuming diatoms, algae, and detritus (USFWS 2002). Tadpoles filter and entrap suspended algae (Seale and Beckvar, 1980) via mouthparts designed for effective grazing of periphyton (Wassersug, 1984, Kupferberg *et al.*; 1994; Kupferberg, 1997; Altig and McDiarmid, 1999).

Juvenile and adult CRLFs forage in aquatic and terrestrial habitats, and their diet differs greatly from that of larvae. The main food source for juvenile aquatic- and terrestrial-phase CRLFs is thought to be aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Hayes and Tennant (1985) report, based on a study examining the gut content of 35 juvenile and adult CRLFs, that the species feeds on as many as 42 different invertebrate taxa, including Arachnida, Amphipoda, Isopoda, Insecta, and Mollusca. The most commonly observed prey species were larval alderflies (*Sialis* cf. *californica*), pillbugs (*Armadilliadrium vulgare*), and water striders (*Gerris* sp). The preferred prey species, however, was the sowbug (Hayes and Tennant, 1985). This study suggests that CRLFs forage primarily above water, although the authors note other data reporting that adults also feed under water, are cannibalistic, and consume fish. For larger CRLFs, over 50% of the prey mass may consists of vertebrates such as mice, frogs, and fish, although aquatic and terrestrial invertebrates were the most numerous food items (Hayes and Tennant 1985). For adults, feeding activity takes place primarily at night; for juveniles feeding occurs during the day and at night (Hayes and Tennant 1985).

2.5.4. Habitat

CRLFs require aquatic habitat for breeding, but also use other habitat types including riparian and upland areas throughout their life cycle. CRLF use of their environment varies; they may complete their entire life cycle in a particular habitat or they may utilize multiple habitat types. Overall, populations are most likely to exist where multiple breeding areas are embedded within varying habitats used for dispersal (USFWS 2002). Generally, CRLFs utilize habitat with perennial or near-perennial water (Jennings et al. 1997). Dense vegetation close to water, shading and water of moderate depth are habitat features that appear especially important for CRLF (Hayes and Jennings 1988).Breeding sites include streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds (land depressions between fault zones that have filled with water), dune ponds, and lagoons. Breeding adults have been found near deep (0.7 m) still or slow moving water surrounded by dense vegetation (USFWS 2002); however, the largest number of tadpoles have been found in shallower pools (0.26 – 0.5 m) (Reis, 1999). Data indicate that CRLFs do not frequently inhabit vernal pools, as conditions in these habitats generally are not suitable (Hayes and Jennings 1988).

CRLFs also frequently breed in artificial impoundments such as stock ponds, although additional research is needed to identify habitat requirements within artificial ponds (USFWS 2002). Adult CRLFs use dense, shrubby, or emergent vegetation closely associated with deep-water pools bordered with cattails and dense stands of overhanging vegetation (http://www.fws.gov/endangered/features/rl_frog/rlfrog.html#where).

In general, dispersal and habitat use depends on climatic conditions, habitat suitability, and life stage. Adults rely on riparian vegetation for resting, feeding, and dispersal. The foraging quality of the riparian habitat depends on moisture, composition of the plant community, and presence of pools and backwater aquatic areas for breeding. CRLFs can be found living within streams at distances up to 3 km (2 miles) from their breeding site and have been found up to 30 m (100 feet) from water in dense riparian vegetation for up to 77 days (USFWS 2002).

During dry periods, the CRLF is rarely found far from water, although it will sometimes disperse from its breeding habitat to forage and seek other suitable habitat under downed trees or logs, industrial debris, and agricultural features (UWFWS 2002). According to Jennings and Hayes (1994), CRLFs also use small mammal burrows and moist leaf litter as habitat. In addition, CRLFs may also use large cracks in the bottom of dried ponds as refugia; these cracks may provide moisture for individuals avoiding predation and solar exposure (Alvarez 2000).

2.6. Designated Critical Habitat

In a final rule published on April 13, 2006, 34 separate units of critical habitat were designated for the CRLF by USFWS (USFWS 2006; FR 51 19244-19346). A summary of the 34 critical habitat units relative to USFWS-designated recovery units and core areas (previously discussed in Section 2.5.1) is provided in **Table 4**.

'Critical habitat' is defined in the ESA as the geographic area occupied by the species at the time of the listing where the physical and biological features necessary for the conservation of the species exist, and there is a need for special management to protect the listed species. It may also include areas outside the occupied area at the time of listing if such areas are 'essential to the conservation of the species.' All designated critical habitat for the CRLF was occupied at the time of listing. Critical habitat receives protection under Section 7 of the ESA through prohibition against destruction or adverse modification with regard to actions carried out, funded, or authorized by a federal Agency. Section 7 requires consultation on federal actions that are likely to result in the destruction or adverse modification of critical habitat.

To be included in a critical habitat designation, the habitat must be 'essential to the conservation of the species.' Critical habitat designations identify, to the extent known using the best scientific and commercial data available, habitat areas that provide essential life cycle needs of the species or areas that contain certain primary constituent elements (PCEs) (as defined in 50 CFR 414.12(b)). PCEs include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species. The designated critical habitat areas for the CRLF are considered to have the following PCEs that justify critical habitat designation:

- Breeding aquatic habitat;
- Non-breeding aquatic habitat;
- Upland habitat; and
- Dispersal habitat.

Please note that a more complete description of these habitat types is provided in Attachment 1.

Occupied habitat may be included in the critical habitat only if essential features within the habitat may require special management or protection. Therefore, USFWS does not include areas where existing management is sufficient to conserve the species. Critical habitat is designated outside the geographic area presently occupied by the species only when a designation limited to its present range would be inadequate to ensure the conservation of the species. For the CRLF, all designated critical habitat units contain all four of the PCEs, and were occupied by the CRLF at the time of FR listing notice in April 2006. The FR notice designating critical habitat for the CRLF includes a special rule exempting routine ranching activities associated with livestock ranching from incidental take prohibitions. The purpose of this exemption is to promote the conservation of rangelands, which could be beneficial to the CRLF, and to reduce the rate of conversion to other land uses that are incompatible with CRLF conservation. Please see Attachment 1 for a full explanation on this special rule.

USFWS has established adverse modification standards for designated critical habitat (USFWS 2006). Activities that may destroy or adversely modify critical habitat are those that alter the PCEs and jeopardize the continued existence of the species. Evaluation of actions related to use of diazinon that may alter the PCEs of the CRLF's critical habitat form the basis of the critical habitat impact analysis. According to USFWS (2006), activities that may affect critical habitat and therefore result in adverse effects to the CRLF include, but are not limited to the following:

1) Significant alteration of water chemistry or temperature to levels beyond the tolerances of the CRLF that result in direct or cumulative adverse effects to individuals and their life-cycles.
2) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat that could result in elimination or reduction of habitat necessary for the growth and reproduction of the CRLF by increasing the sediment deposition to levels that would adversely affect their ability to complete their life cycles.
3) Significant alteration of channel/pond morphology or geometry that may lead to changes to the hydrologic functioning of the stream or pond and alter the timing, duration, water flows, and levels that would degrade or eliminate the CRLF and/or its habitat. Such an effect could also lead to increased sedimentation and degradation in water quality to levels that are beyond the CRLF's tolerances.
4) Elimination of upland foraging and/or aestivating habitat or dispersal habitat.
5) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
6) Alteration or elimination of the CRLF's food sources or prey base (also evaluated as indirect effects to the CRLF).

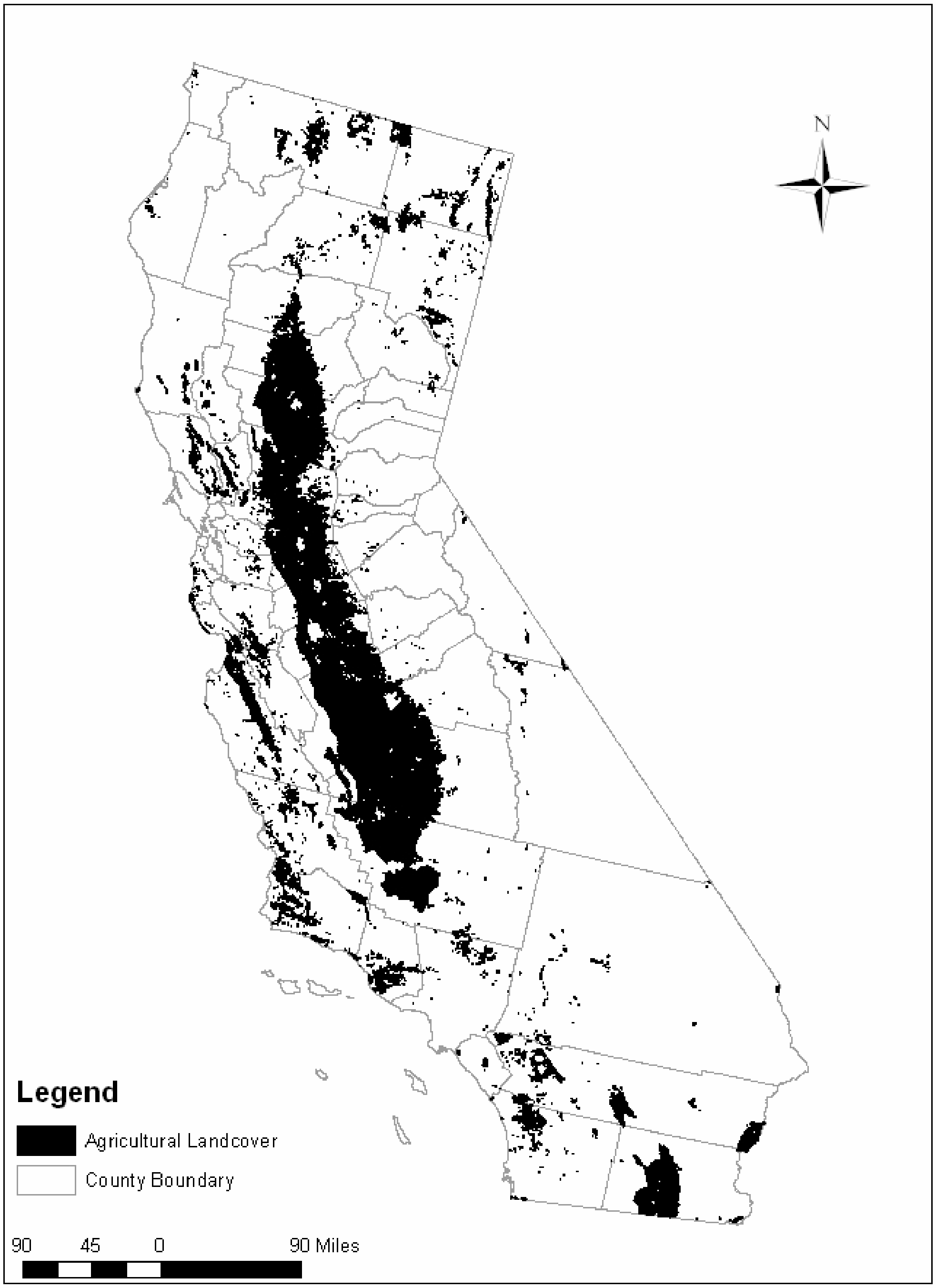
As previously noted in Section 2.1, the Agency believes that the analysis of direct and indirect effects to listed species provides the basis for an analysis of potential effects on the designated critical habitat. Because diazinon is expected to directly impact living organisms within the action area, critical habitat analysis for diazinon is limited in a practical sense to those PCEs of critical habitat that are biological or that can be reasonably linked to biologically mediated processes.

2.7. Action Area

For listed species assessment purposes, the action area is considered to be the area affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). It is recognized that the overall action area for the national registration of diazinon is likely to encompass considerable portions of the United States based on the large array of uses on fruits, nuts, vegetables and ornamentals. However, the scope of this assessment limits consideration of the overall action area to those portions that may be applicable to the protection of the CRLF and its designated critical habitat within the State of California. Deriving the geographical extent of this portion of the action area is the product of consideration of the types of effects that diazinon may be expected to have on the environment, the exposure levels to diazinon that are associated with those effects, and the best available information concerning the use of diazinon and its fate and transport within the State of California.

The definition of action area requires a stepwise approach that begins with an understanding of the federal action. The federal action is defined by the currently labeled uses for diazinon. An analysis of labeled uses and review of available product labels was completed. This analysis indicates that, for diazinon, the following uses are considered as part of the federal action evaluated in this assessment: almonds, blueberries, caneberries, cattle ear tags, cranberries, fig, ginseng, leafy vegetables (spinach, endive), lettuce, melons (cantaloupes, casabas, crenshaws, honeydews, muskmelons, Persians, watermelons), outdoor ornamentals, pineapples, root crops (onions, radishes), row crops (carrots, beans, peppers (bell and chili), peas (succulent), beets (red)), strawberries, tomatoes, tree fruit (apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes), and tuber crops (rutabagas and sweet potatoes). As stated above, applications of diazinon to ginseng, cranberries, pineapples are not assessed since the crops are not grown in California. Also, use of diazinon in cattle ear tags is not assessed because exposure to the CRLF is expected to be *deminimus* based on consideration of the fate of diazinon contained in the tags.

After determination of which uses will be assessed, an evaluation of the potential "footprint" of the use pattern is determined. This "footprint" represents the initial area of concern and is typically based on available land cover data. Local land cover data available for the state of California were analyzed to refine the understanding of potential diazinon use. The initial area of concern is defined as all land cover types that represent the labeled uses described above. The initial area of concern is represented by 1) agricultural landcovers, which are assumed to represent vegetable and non-orchard fruit crops as well as ornamental crops and 2) orchard and vineyard landcovers which are assumed to be representative of tree fruit and almond crops. Maps representing the land cover types that make up the initial areas of concern for agricultural and orchard crops are presented in **Figures 4 and 5,** respectively. These maps represent the areas directly affected by the federal action.



Compiled from California County boundaries (ESRI, 2002),
USDA National Agriculture Statistical Service (NASS, 2002)
Gap Analysis Program Orchard/ Vineyard Landcover (GAP)
National Land Cover Database (NLCD) (MRLC, 2001)

Map created by U.S. Environmental Protection Agency,
Office of Pesticides Programs, Environmental Fate and
Effects Division. April 11, 2007.
Projection: Albers Equal Area Conic USGS,
North American Datum of 1983 (NAD 1983)

Figure 4. Initial action area for crops described by agricultural landcover which corresponds to potential diazinon use sites. This map represents the area potentially directly affected by the federal action.

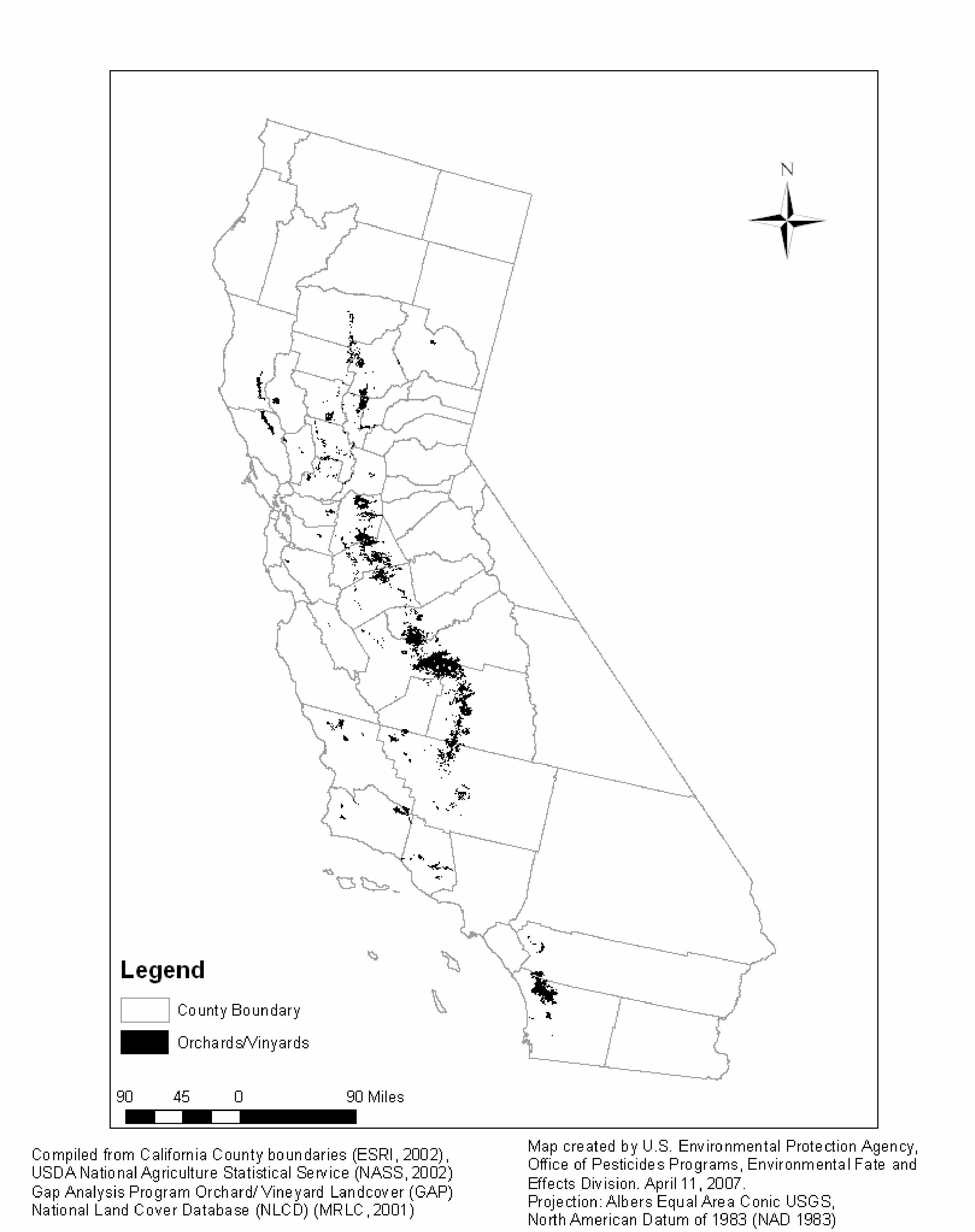


Figure 5. Initial action area for crops described by orchard and vineyard landcover which corresponds to potential diazinon use sites on tree fruit and almonds. This map represents the area potentially directly affected by the federal action.

Once the initial area of concern is defined, the next step is to compare the extent of that area with the results of the screening level risk assessment. The environmental fate properties of diazinon along with monitoring data identifying its presence in surface waters, air and precipitation in California indicate that runoff, spray drift, volatilization and atmospheric transport and (wet) deposition represent significant potential transport mechanisms of diazinon to the aquatic and terrestrial habitats of the CRLF. Therefore, there is potential for diazinon to be transported outside of the area where it is directly applied to areas where it is not directly applied. In this assessment, transport of diazinon through runoff and spray drift is considered in deriving quantitative estimates of diazinon exposure to CRLF, its prey and its habitats. Although volatilization of diazinon from treated areas resulting in atmospheric transport and deposition represent relevant transport pathways leading to exposure of the CRLF and its habitats, adequate tools are unavailable at this time to quantify exposures through these pathways. Therefore, consideration of influences of runoff and spray drift in expanding the action area through indirect exposures is used in the derivation of the final action area. Although volatilization, atmospheric transport and deposition are not considered quantitatively, it is possible that the final action area identified in the risk discussion is actually larger because of these transport pathways.

Since this screening level risk assessment defines taxa that are predicted to be exposed through runoff and drift to diazinon at concentrations above the Agency's Levels of Concern (LOC), there is need to expand the action area to include areas that are affected indirectly by this federal action. Two methods are employed to define the areas indirectly affected by the federal action, and thus the total action area. These are the down stream dilution assessment for determining the extent of the affected lotic aquatic habitats (flowing water) and the spray drift assessment for determining the extent of the affected terrestrial habitats. In order to define the final action areas relevant to uses of diazinon on agricultural and orchard crops, it is necessary to combine areas directly affected, as well as aquatic and terrestrial habitats indirectly affected by the federal action. It is assumed that lentic (standing water) aquatic habitats (*e.g.* ponds, pools, marshes) overlapping with the terrestrial areas are also indirectly affected by the federal action. **The analysis of areas indirectly affected by the federal action, as well as the determination of the final action area for diazinon is described in the risk discussion (Section 5.2.4). Additional analysis related to the intersection of the diazinon action area and CRLF habitat used in determining the final action area is described in Appendix K.**

2.8. Assessment Endpoints and Measures of Ecological Effect

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected" (USEPA 1992). Selection of the assessment endpoints is based on valued entities (*e.g.*, CRLF, organisms important in the life cycle of the CRLF, and the PCEs of its designated critical habitat), the ecosystems potentially at risk (*e.g.*, waterbodies, riparian vegetation, and upland and dispersal habitats), the migration pathways of diazinon (*e.g.*, runoff, spray drift, etc.), and the routes by which ecological receptors are exposed to diazinon -related contamination (*e.g.*, direct contact, etc).

2.8.1. Assessment Endpoints for the CRLF

Assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. In addition, potential destruction and/or adverse modification of critical habitat is assessed by evaluating potential effects to PCEs, which are components of the habitat areas that provide essential life cycle needs of the CRLF. Each assessment endpoint requires one or more "measures of ecological effect," defined as changes in the attributes of an assessment endpoint or changes in a surrogate entity or attribute in response to exposure to a pesticide. Specific measures of ecological effect are generally evaluated based on acute and chronic toxicity information from registrant-submitted guideline tests that are performed on a limited number of organisms. Additional ecological effects data from the open literature are also considered.

A complete discussion of all the toxicity data available for this risk assessment, including resulting measures of ecological effect selected for each taxonomic group of concern, is included in Section 4 of this document. A summary of the assessment endpoints and measures of ecological effect selected to characterize potential assessed direct and indirect CRLF risks associated with exposure to diazinon is provided in **Table 5**. All registrant-submitted and open literature toxicity data reviewed for this assessment are included in **Appendix A**. Available information indicates that the CRLF does not have any obligate relationships with aquatic, semi-aquatic or terrestrial plants.

Table 5. Summary of Assessment Endpoints and Measures of Ecological Effects for Direct and Indirect Effects of diazinon on the California Red-legged Frog.

Assessment Endpoint	Measures of Ecological Effects
Aquatic Phase (eggs, larvae, tadpoles, juveniles, and adults)[a]	
1. Survival, growth, and reproduction of CRLF individuals via direct effects on aquatic phases	1a. Rainbow trout acute LC_{50} 1b. Brook trout chronic NOAEC
2. Survival, growth, and reproduction of CRLF individuals via effects to food supply (*i.e.*, freshwater invertebrates, non-vascular plants)	2a. Waterflea acute EC_{50} 2b. Waterflea chronic NOAEC 2c. Algae EC_{50}
3. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat, cover, and/or primary productivity (*i.e.*, aquatic plant community)	3a. Non-vascular plant acute EC_{50} (freshwater algae or diatom, or ECOTOX non-vascular)
4. Survival, growth, and reproduction of CRLF individuals via effects to riparian vegetation, required to maintain acceptable water quality and habitat in ponds and streams comprising the species' current range.	4a. Distribution of EC_{25} values for monocots (seedling emergence and vegetative vigor) 4b. Distribution of EC_{25} values for dicots (seedling emergence and vegetative vigor)
Terrestrial Phase (Juveniles and adults)	
5. Survival, growth, and reproduction of CRLF individuals via direct effects on terrestrial phase adults and juveniles	5a. Mallard acute LD_{50} 5b. Mallard subacute LC_{50} 5b. Mallard chronic NOAEC
6. Survival, growth, and reproduction of CRLF individuals via effects on prey (*i.e.,*terrestrial invertebrates, small terrestrial vertebrates, including mammals and terrestrial phase amphibians)	6a. Honeybee acute contact LD_{50} 6b. Most sensitive terrestrial mammal acute LD_{50} 6c. Most sensitive terrestrial mammal chronic NOAEC 6d. Mallard acute LD_{50} 6e. Mallard subacute LC_{50} 6f. Mallard chronic NOAEC
7. Survival, growth, and reproduction of CRLF individuals via indirect effects on habitat (*i.e.*, riparian vegetation)	7a. Distribution of EC_{25} values for monocots (seedling emergence and vegetative vigor) 7b. Distribution of EC_{25} values for dicots (seedling emergence and vegetative vigor)

[a] Adult frogs are no longer in the "aquatic phase" of the amphibian life cycle; however, submerged adult frogs are considered "aquatic" for the purposes of this assessment because exposure pathways in the water are considerably different that exposure pathways on land.
[b] Birds are used as surrogates for terrestrial phase amphibians.
[c] Although the most sensitive toxicity value is initially used to evaluate potential indirect effects, sensitivity distribution is used (if sufficient data are available) to evaluate the potential impact to food items of the CRLF.

2.8.2. Assessment Endpoints for Designated Critical Habitat

As previously discussed, designated critical habitat is assessed to evaluate actions related to the use of diazinon that may alter the PCEs of the CRLF's critical habitat. PCEs for the CRLF were previously described in Section 2.6. Actions that may destroy or adversely modify critical habitat are those that alter the PCEs. Therefore, these actions are identified as assessment endpoints. It should be noted that evaluation of PCEs as assessment endpoints is limited to those of a biological nature (i.e., the biological resource requirements for the listed species associated with the critical habitat) and those for which diazinon effects data are available.

Assessment endpoints and measures of ecological effect selected to characterize potential modification to designated critical habitat associated with exposure to diazinon are provided in **Table 6**. Adverse modification to the critical habitat of the CRLF includes the following, as specified by USFWS (2006) and previously discussed in Section 2.6:

1) Alteration of water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs.
2) Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.
3) Significant increase in sediment deposition within the stream channel or pond or disturbance of upland foraging and dispersal habitat.
4) Significant alteration of channel/pond morphology or geometry.
5) Elimination of upland foraging and/or aestivating habitat, as well as dispersal habitat.
6) Introduction, spread, or augmentation of non-native aquatic species in stream segments or ponds used by the CRLF.
7) Alteration or elimination of the CRLF's food sources or prey base.

Measures of such possible effects by labeled use of diazinon on critical habitat of the CRLF are described in **Table 6**. Some components of these PCEs are associated with physical abiotic features (e.g., presence and/or depth of a water body, or distance between two sites), which are not expected to be measurably altered by use of pesticides. Assessment endpoints used for the analysis of designated critical habitat are based on the adverse modification standard established by USFWS (2006).

Table 6. Summary of Assessment Endpoints and Measures of Ecological Effect for Primary Constituent Elements of Designated Critical Habitat.

Assessment Endpoint	Measures of Ecological Effect
Aquatic-Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)	
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	a. Most sensitive aquatic plant EC_{50} b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence, vegetative vigor) c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor)
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.*	a. Non-vascular plant acute EC_{50} (freshwater algae) b. Distribution of EC_{25} values for terrestrial monocots (seedling emergence or vegetative vigor) c. Distribution of EC_{25} values for terrestrial dicots (seedling emergence, vegetative vigor)
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	a. Rainbow trout acute LC_{50} b. Brook trout chronic NOAEC c. Waterflea acute EC_{50} d. Waterflea chronic NOAEC
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	a. Algae EC_{50}
Terrestrial-Phase PCEs (Upland Habitat and Dispersal Habitat)	
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	a. Distribution of EC_{25} values for monocots (seedling emergence, vegetative vigor) b. Distribution of EC_{25} values for dicots (seedling emergence, vegetative vigor) c. Most sensitive food source acute EC_{50}/LC_{50} and NOAEC values for terrestrial vertebrates (mammals) and invertebrates, birds or terrestrial-phase amphibians, and freshwater fish.
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	

* Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

2.9. Conceptual Model

2.9.1. Risk Hypotheses

Risk hypotheses are specific assumptions about potential adverse effects (i.e., changes in assessment endpoints) and may be based on theory and logic, empirical data, mathematical models, or probability models (U.S. EPA, 1998). For this assessment, the risk is stressor-linked, where the stressor is the release of diazinon to the environment. The following risk hypotheses are presumed for this endangered species assessment:

- Labeled uses of diazinon within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;
- Labeled uses of diazinon within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;
- Labeled uses of diazinon within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;
- Labeled uses of diazinon within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

2.9.2. Diagram

The conceptual model is a graphic representation of the structure of the risk assessment. It specifies the stressor (diazinon), release mechanisms, biological receptor types, and effects endpoints of potential concern. The conceptual models for aquatic and terrestrial phases of the CRLF are shown in **Figures 6** and **7**, and the conceptual models for the aquatic and terrestrial PCE components of critical habitat are shown in **Figures 8** and **9**.

The environmental fate properties of diazinon along with monitoring data identifying its presence in surface waters, air and precipitation in California indicate that runoff, spray drift, volatilization and atmospheric transport and (wet) deposition represent significant potential transport mechanisms of diazinon to the aquatic and terrestrial habitats of the CRLF. These transport properties (e.g. sources) are depicted in the conceptual models below (**Figures 6-9**) along with the receptors of concern and the potential attribute changes in the receptors due to exposures to diazinon.

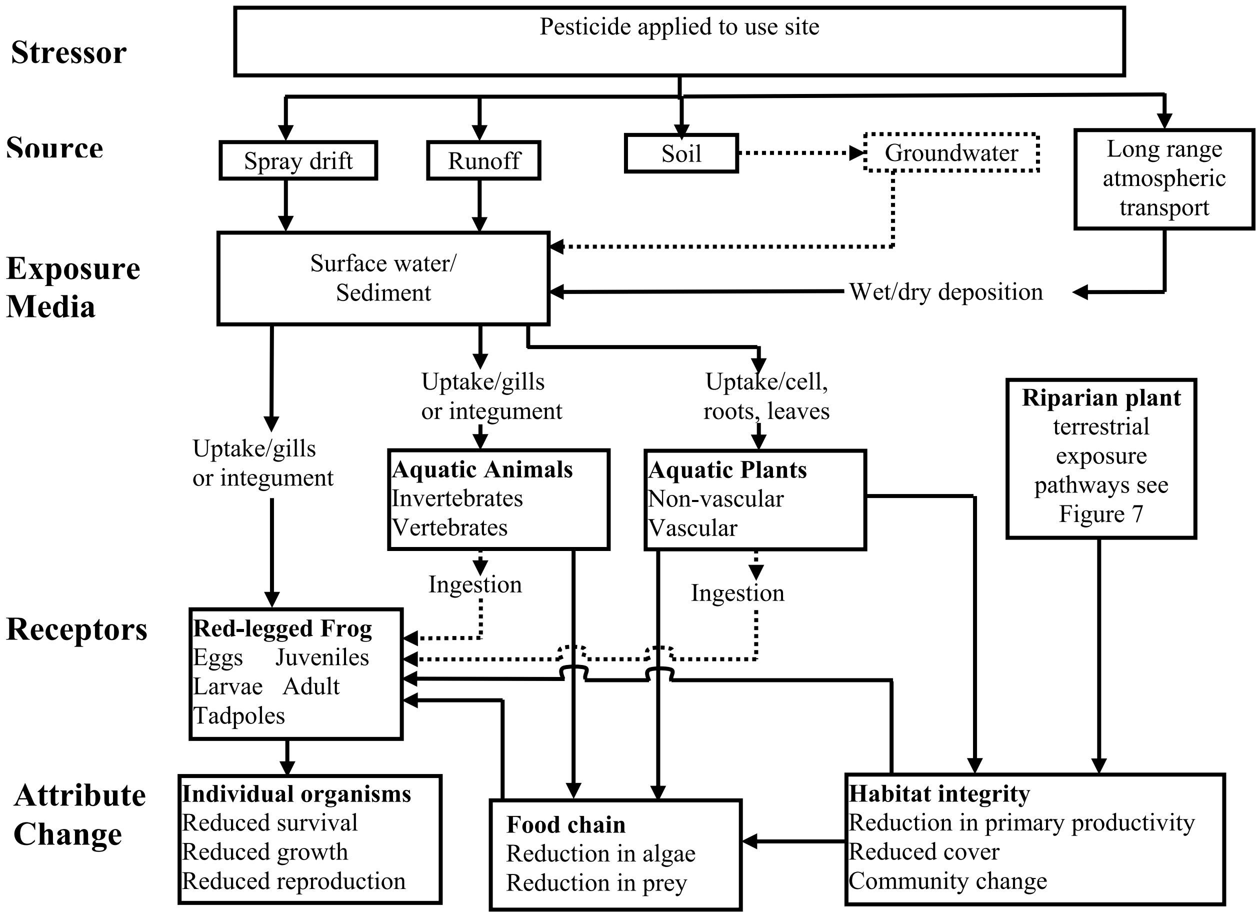


Figure 6. Conceptual model for diazinon effects on aquatic phase of the red-legged frog.

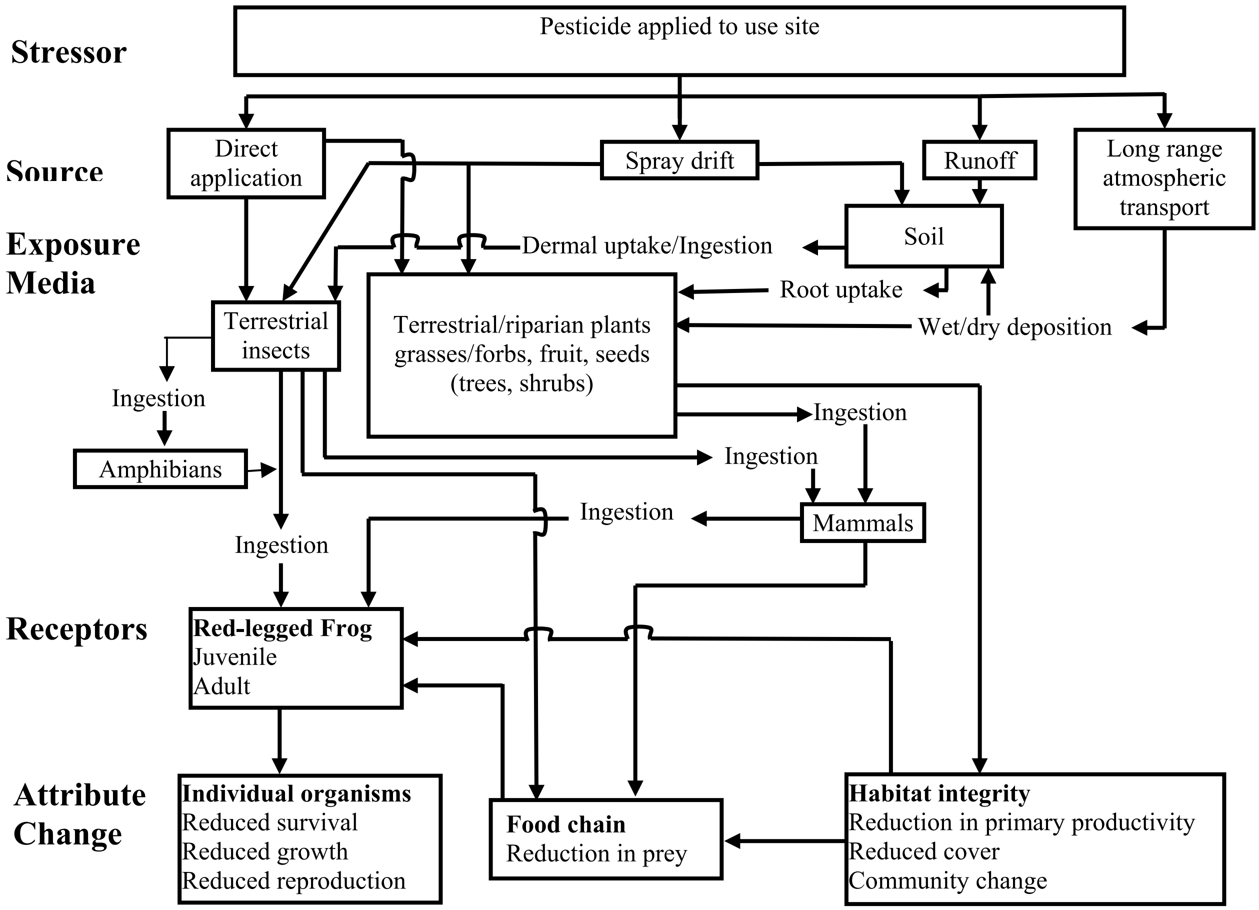


Figure 7. Conceptual model for diazinon effects on terrestrial phase of the red-legged frog.

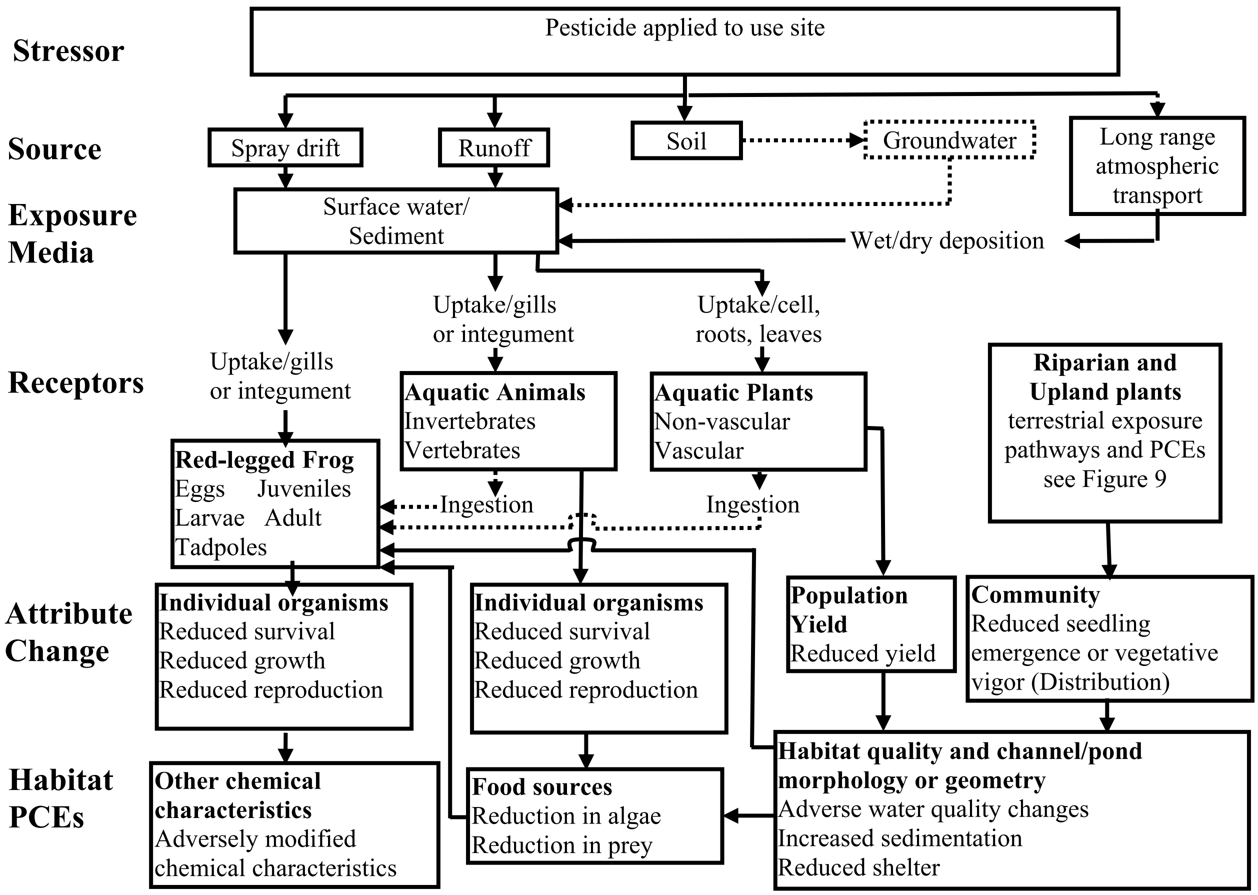


Figure 8. Conceptual Model for diazinon Effects on Aquatic Component of Red-Legged Frog Critical Habitat.

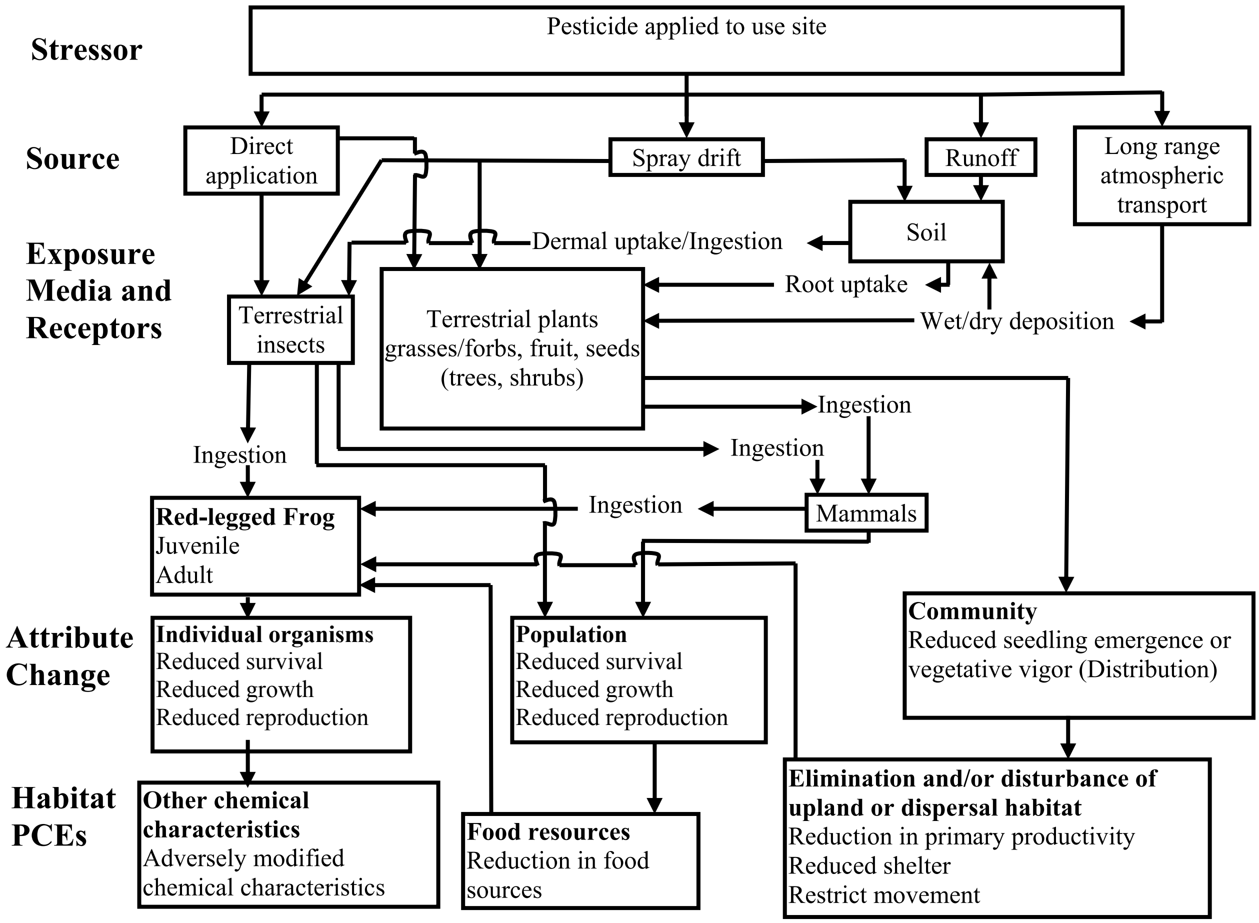


Figure 9. Conceptual Model for diazinon Effects on Terrestrial Component of the Red-Legged Frog Critical Habitat.

2.10. Analysis Plan

In order to address the risk hypothesis, the potential for adverse effects on the CRLF, its prey and its habitat is estimated. In the following sections, the use, environmental fate, and ecological effects of diazinon are characterized and integrated to assess the risks. This is accomplished using a risk quotient (ratio of exposure concentration to effects concentration) approach. Although risk is often defined as the likelihood and magnitude of adverse ecological effects, the risk quotient-based approach does not provide a quantitative estimate of likelihood and/or magnitude of an adverse effect. However, as outlined in the Overview Document (USEPA 2004), the likelihood of effects to individual organisms from particular uses of diazinon is estimated using the probit dose-response slope and either the level of concern (discussed below) or actual calculated risk quotient value.

2.10.1. Measures to Evaluate the Risk Hypothesis and Conceptual Model

2.10.1.1. Measures of Exposure

The environmental fate properties of diazinon along with monitoring data identifying its presence in surface water, in air and in precipitation in California indicate that runoff, spray drift, volatilization, atmospheric transport and subsequent deposition represent potential transport mechanisms of diazinon to the aquatic and terrestrial habitats of the CRLF. In this assessment, transport of diazinon through runoff and spray drift is considered in deriving quantitative estimates of diazinon exposure to CRLF, its prey and its habitats. Although volatilization of diazinon from treated areas resulting in atmospheric transport and deposition represent relevant transport pathways leading to exposure of the CRLF and its habitats, adequate tools are unavailable at this time to quantify exposures through these pathways. Therefore, volatilization, atmospheric transport and wet and dry deposition from the atmosphere are only discussed qualitatively in this assessment.

Measures of exposure are based on aquatic and terrestrial models that predict estimated environmental concentrations (EECs) of diazinon using maximum labeled application rates and methods. The models used to predict aquatic EECs are the Pesticide Root Zone Model coupled with the Exposure Analysis Model System (PRZM/EXAMS). The model used to predict terrestrial EECs on food items is T-REX. The model used to derive EECs relevant to terrestrial and wetland plants was TerrPlant. These models are parameterized using relevant reviewed registrant-submitted environmental fate data.

PRZM (v3.12beta, May 24, 2001) and EXAMS (v2.98.04, Aug. 18, 2002) are screening simulation models coupled with the input shell pe4v01.pl (Aug.8, 2003) to generate daily exposures and 1-in-10 year EECs of diazinon that may occur in surface water bodies adjacent to application sites receiving diazinon through runoff and spray drift. PRZM simulates pesticide application, movement and transformation on an agricultural field and the resultant pesticide loadings to a receiving water body via runoff, erosion and spray drift. EXAMS simulates the fate of the pesticide and resulting concentrations in the water body. The standard scenario used for ecological pesticide assessments assumes application to a 10-hectare agricultural field that drains into an adjacent 1-hectare water body that is 2 meters deep (20,000 m^3 volume) with no outlet. PRZM/EXAMS is used to estimate screening-level exposure of aquatic organisms to diazinon. The measure of exposure for aquatic species is the 1-in-10 year return peak or rolling mean concentration. The 1-in-10 year peak is used for estimating acute exposures of direct effects to the CRLF, as well as indirect effects to the CRLF through effects to potential prey items, including: algae, aquatic invertebrates, fish and frogs. The 1-in-10-year 60-day mean is used for assessing chronic exposure to the CRLF and fish and frogs serving as prey items. The 1-in-10-year 21-day mean is used for assessing aquatic invertebrate chronic exposure, which are also potential prey items.

Exposure estimates for terrestrial phase CRLF and terrestrial invertebrates and mammals (serving as potential prey) assumed to be in the target area or in an area exposed to spray drift are derived using the T-REX model (version 1.3.1, 12/07/2006). This model incorporates the Kenega nomograph, as modified by Fletcher *et al.* (1994), which is based on a large set of actual field residue data. The upper limit values from the nomograph represented the 95th percentile of residue values from actual field measurements (Hoerger and Kenega, 1972). The Fletcher *et al.* (1994) modifications to the Kenega nomograph are based on measured field residues from 249 published research papers, including information on 118 species of plants, 121 pesticides, and 17 chemical classes. These modifications represent the 95^{th} percentile of the expanded data set. For modeling purposes, direct exposures of the CRLF to diazinon through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey (small mammals) are assessed using the small mammal (15 g) which consumes short grass. The small bird (20g) consuming small insects and the small mammal (15g) consuming short grass are used because these categories represent the largest RQs of the size and dietary categories in T-REX that are appropriate surrogates for the CRLF and one of its prey items. Estimated exposures of terrestrial insects to diazinon are bound by using the dietary based EECs for small insects and large insects.

EECs for terrestrial plants inhabiting dry and wetland areas are derived using TerrPlant (version 1.2.2, 12/26/2006). This model uses estimates of pesticides in runoff and in spray drift to calculate EECs. EECs are based upon solubility, application rate and minimum incorporation depth.

Two spray drift models, AGDisp and AgDRIFT are used to assess exposures of terrestrial phase CRLF and its prey to diazinon deposited on terrestrial habitats by spray drift. AGDisp (version 8.13; dated 12/14/2004) (Teske and Curbishley 2003) is used to simulate aerial and ground applications using the Gaussian farfield extension. AgDrift (version 2.01; dated 5/24/2001) is used to simulate spray blast applications to orchard crops.

2.10.1.2. Measures of Effect

Data identified in Section 2.8 are used as measures of effect for direct and indirect effects to the CRLF. Data were obtained from registrant submitted studies or from literature studies identified by ECOTOX. The ECOTOXicology database (ECOTOX) was searched in order to provide more ecological effects data and in an attempt to bridge existing data gaps. ECOTOX is a source for locating single chemical toxicity data for aquatic life, terrestrial plants, and wildlife. ECOTOX was created and is maintained by the USEPA, Office of Research and Development, and the National Health and Environmental Effects Research Laboratory's Mid-Continent Ecology Division (ECOTOX, 2006).

The assessment of risk for direct effects to the CRLF makes the assumption that toxicity of diazinon to birds is similar to terrestrial-phase CRLF. The same assumption is made for fish and aquatic-phase CRLF. Algae, aquatic invertebrates, fish and amphibians represent potential prey of the CRLF in the aquatic habitat. Terrestrial invertebrates, small mammals, and terrestrial phase amphibians represent potential prey of the CRLF in the terrestrial habitat. Aquatic plants and semi-aquatic plants represent habitat of CRLF.

The acute measures of effect used for animals in this screening level assessment are the LD_{50}, LC_{50} and EC_{50}. LD stands for "Lethal Dose", and LD_{50} is the amount of a material, given all at once, that is estimated to cause the death of 50% of the test organisms. LC stands for "Lethal

Concentration" and LC_{50} is the concentration of a chemical that is estimated to kill 50% of the test organisms. EC stands for "Effective Concentration" and the EC_{50} is the concentration of a chemical that is estimated to produce a specific effect in 50% of the test organisms. Endpoints for chronic measures of exposure for listed and non-listed animals are the NOAEL/NOAEC and NOEC. NOAEL stands for "No Observed-Adverse-Effect-Level" and refers to the highest tested dose of a substance that has been reported to have no harmful (adverse) effects on test organisms. The NOAEC (*i.e.*, "No-Observed-Adverse-Effect-Concentration") is the highest test concentration at which none of the observed effects were statistically different from the control. The NOEC is the No-Observed-Effects-Concentration. For non-listed plants, only acute exposures are assessed (*i.e.*, EC_{25} for terrestrial plants and EC_{50} for aquatic plants).

2.10.1.3. Integration of Exposure and Effects

Risk characterization is the integration of exposure and ecological effects characterization to determine the potential ecological risk from the use of diazinon on fruits, nuts, vegetables and ornamentals, and the likelihood of direct and indirect effects to CRLF in aquatic and terrestrial habitats. The exposure and toxicity effects data are integrated in order to evaluate the risks of adverse ecological effects on non-target species. For the assessment of diazinon risks, the risk quotient (RQ) method is used to compare exposure and measured toxicity values. EECs are divided by acute and chronic toxicity values. The resulting RQs are then compared to the Agency's levels of concern (LOCs) (USEPA, 2004) (see **Table 7**). These criteria are used to indicate when diazinon's uses, as directed on the label, have the potential to cause adverse direct or indirect effects to the CRLF.

Table 7. Agency risk quotient (RQ) metrics and levels of concern (LOC) per risk class.

Risk Class	Description	RQ	LOC
Aquatic Habitats			
Acute Listed Species	CRLF may be potentially affected by use by direct or indirect effects.	Peak EEC/EC_{50}[1]	0.05
Acute Non-Listed Species	CRLF may be potentially affected by use by indirect effects through effects to animal prey (i.e. invertebrates, fish and aquatic-phase amphibians).	Peak EEC/EC_{50}[1]	0.5
Chronic Listed and Non-Listed Species	Potential for chronic risk to CRLF through direct or indirect effects. Indirect effects represented by effects to invertebrates, fish or amphibians, which represent potential prey.	60-day EEC/NOEC (CRLF) 21-day EEC/NOEC (invertebrates)	1
Non-Listed	Potential for effects in non-listed plants.	Peak EEC/ EC_{50}	1
Terrestrial Habitats			
Acute Listed Species	CRLF may be potentially affected by use by direct or indirect effects.	Dietary EEC [2]/LC_{50} Or Dose EEC [2]/LD_{50}	0.1
Acute Listed Species	Potential effects to terrestrial invertebrates. CRLF may be potentially affected by use by direct or indirect effects.	EEC [2]/LD_{50}	0.05
Acute Non-Listed Species	CRLF may be potentially affected by use by indirect effects through effects to animal prey (i.e. mice and terrestrial-phase amphibians).	Dietary EEC [2]/LC_{50} Or Dose EEC [2]/LD_{50}	0.5
Chronic Listed Species	Potential for chronic risk to CRLF through direct or indirect effects. Indirect effects represented by effects to small mammals, which represent potential prey.	EEC [2]/NOAEC	1
Non-Listed	Potential for effects in non-listed plants.	Peak EEC/ EC_{25}	1

[1] LC_{50} or EC_{50}.
[2] Based on upper-bound Kenaga values.

For this endangered species assessment, listed species LOCs are used for comparing RQ values for acute and chronic exposures of diazinon directly to the CRLF. If estimated exposures directly to the CRLF of diazinon resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is LAA. When considering indirect effects to the CRLF due to effects to animal prey (aquatic and terrestrial invertebrates, fish, frogs and mice), the listed species LOCs are also used. If estimated exposures to CRLF prey of diazinon resulting from a particular use are sufficient to exceed the listed species LOC, then the effects determination for that use is a "may affect." If the RQ being considered also exceeds the non-listed species LOC, then the effects determination is a LAA. If the RQ is between the listed species LOC and the non-listed species LOC, then further lines of evidence (*i.e*. probability of individual effects, species sensitivity distributions) are considered in distinguishing between a determination of NLAA and a LAA. When considering indirect effects to the CRLF due to effects to algae as dietary items or plants as habitat, the non-listed species LOC for plants is used. If the RQ being considered for a particular use exceeds the non-listed species LOC, then the effects determination is LAA.

2.10.2. Data Gaps

No data are available for assessing the effects of exposures of diazinon to freshwater, vascular plants. Generally, data for duckweed (*Lemna gibba*) are used to assess these effects. Given the mode of action of diazinon in combination with the anatomy of plants, as well as the relatively low toxicity of diazinon to non-vascular, aquatic plants (green algae) and to terrestrial plants, this data gap is not of particular concern for this risk assessment. However, this data gap represents an uncertainty in the assessment of potential risk to the CRLF, its prey and its habitat.

Additionally, at this time, there are no data available on the anaerobic aquatic metabolism half-life for diazinon. Thus the extent to which diazinon is subject to biotic degradation in areas where there is low oxygen is uncertain.

3. Exposure Assessment

3.1. Aquatic Exposure Assessment

3.1.1. Existing Water Monitoring Data for California

EFED finalized the Environmental Fate and Ecological Risk assessment for diazinon in 2000. That assessment contained an aquatic exposure assessment (including drinking water) as well as an ecological risk assessment. The data included in that risk assessment and the conclusions associated with the data are briefly described below. For more detailed information, see USEPA 2000. Since the risk assessment was completed, EFED has obtained additional diazinon monitoring data and summarizes the California-specific data below. These data include United States Geological Survey's (USGS) National Water Quality Assessment (NAWQA), several USGS reports from California-specific studies which were prepared in cooperation with the California Department of Pesticide Regulation (CDPR), the CDPR Surface Water Database and a total maximum daily load (TMDL) monitoring report from the Central Valley.

3.1.1.1. Previous Assessment

A number of National and California-specific surface water monitoring studies are discussed in the Environmental Fate and Ecological Risk Assessment supporting the IRED for Diazinon (USEPA 2000). Sources of monitoring data used in that assessment included: NAWQA (USGS, 1998) and National Stream Water Quality Network (NASQAN) (USGS, 1999) programs, the Permit Compliance System (PCS) database for National Pollutant Discharge Elimination System (NPDES) permits (USEPA, 1998), National Survey of Pesticide in Drinking Water (NPS) (USEPA, 1990), California State**,** and the open literature**.** The major conclusions resulting from consideration of these data are outlined below.

- Non-agricultural uses of diazinon, including homeowner uses, appear to have significantly affected surface water quality before the year 2000.

- Monitoring data indicate widespread occurrence of diazinon in surface water nationally. Diazinon was the most frequently detected insecticide in surface water in the NAWQA program. Diazinon was detected in every major river basin, including the Mississippi, Columbia, Rio Grande, and Colorado, in the USGS NASQAN study.

- Diazinon is widely used in California and for this reason, a great deal of surface water monitoring has been conducted by several agencies from 1992 to 1998. Previous to the IRED publication, diazinon had been detected in the San Joaquin River, the Sacramento River, the Merced River, Russian River, the Tuolumne River, Orestimba Creek, and the Stanislaus River.

- Diazinon residues have been found in large rivers and major aquifers in the U.S.

- Dormant spray use of diazinon has resulted in surface-water contamination in California.

3.1.1.2. NAWQA Data (2000-2005) for California

NAWQA monitoring data are available for diazinon from California surface waters (USGS 2007) (**Table 8**). Although this monitoring does not target specific chemicals, diazinon was detected in 77% of 1285 samples from 2000-2005, with a maximum concentration of 1.06 μg/L.

Table 8. NAWQA 2002 - 2005 data for diazinon detections [1,2] in CA surface waters. Data are distinguished by the landcover (e.g. agricultural, urban, etc.) of the watershed of the sampled water bodies.

Statistics	Agricultural	Mixed	Urban	Other	Total
Number Detections	255	549	116	72	992
% Detects	83.6	74.6	85.9	66.1	77.2
Maximum Concentration (μg/L)	**1.060**	**0.584**	**0.947**	**0.359**	**1.060**
Average Concentration (μg/L)	0.048	0.031	0.157	0.082	0.053
Standard Deviation (μg/L)	0.114	0.053	0.231	0.087	0.115
90^{th} percentile concentration (μg/L)	0.099	0.073	0.547	0.256	0.123

[1]Excludes samples identified by "<", which signify non-detections.

[2]Method detection limit = 0.002 μg/L

NAQWA data are defined by the landcover composition of the watershed of the surface waters from which samples were taken. As stated previously, both residential and agricultural uses were permitted before 2005. On December 5, 2000, EPA announced the agreement to first phase out and then cancel all residential uses of diazinon. The terms of the four-year phase-out stipulated that technical registrants reduce the amount of diazinon produced by 50% or more by 2003. Since December 31, 2004, it has been unlawful to sell diazinon products for residential use. Now, diazinon use is permitted for agricultural uses, but not for residential uses. Available NAWQA data from surface waters with urban landcovers (relevant to residential uses) and agricultural landcovers (relevant to agricultural uses) are described separately below. For the purposes of this assessment, monitoring data from watersheds with agricultural landcovers are most relevant to current diazinon use patterns in California.

3.1.1.2.1. Agricultural landcovers

Since agricultural uses of diazinon are still permitted, samples taken from waters within agricultural watersheds are of interest in the context of this assessment. Of the 305 samples taken from California surface waters with agricultural watersheds, diazinon was detected in 77% of the samples, with a maximum concentration of 1.06 μg/L. This maximum concentration is two orders of magnitude greater than the concentration (*i.e.*, 0.0105 μg/L) that would result in an exceedance of the listed species LOC for aquatic invertebrates. Of the NAWQA monitoring data from California surface waters with agricultural watersheds (including detected concentrations, non-detections and estimated concentrations), 51% of samples contained concentrations of diazinon that were greater than 0.0105 μg/L, the concentration that would exceed the invertebrate acute LOC (**Figure 10**).

From 2000-2005, there were a total of 14 sampled surface water sites in California with agricultural watersheds, with 9 of these sampled more than 10 times. Of these 9 sites, diazinon was detected in 52-94% of samples. Mean detected concentrations ranged 0.020-0.101 μg/L, while the 90^{th} percentile of detected concentrations ranged from 0.042 to 0.231 μg/L (**Table 9**).

Consideration of available monitoring data from between 2000 and 2005, may suggest that diazinon concentrations declined in surface waters with agricultural watersheds (**Figure 10**). However, it is possible that this decline could be attributed to disproportionate sampling over time and influences of different sampling strategies (*e.g.* some data involve diazinon-targeted monitoring projects, while others did not). USGS monitoring studies specifically targeting diazinon are discussed below.

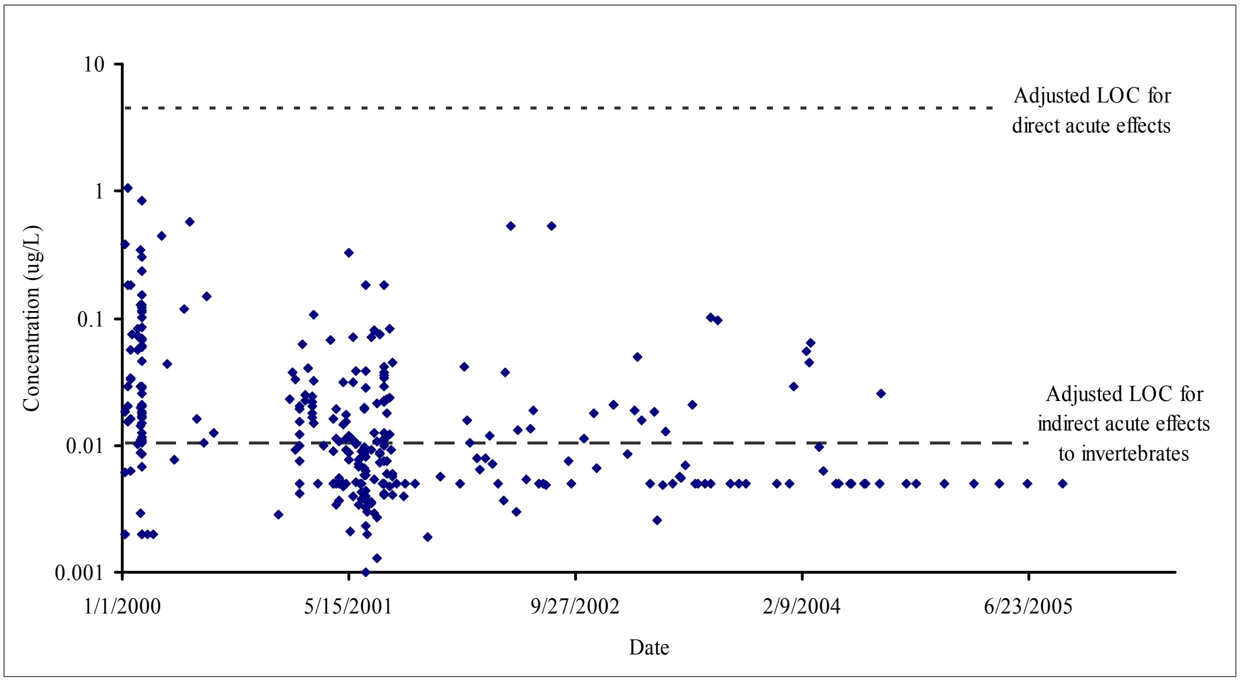


Figure 10. Concentrations of diazinon in CA surface waters with agricultural watersheds (includes detections, estimations and non-detections). Bottom dashed line represents the concentration that would result in an exceedance of the listed species LOC for aquatic invertebrates (indirect effects to forage base of CRLF); upper dotted line represents the concentration that would exceed the listed species LOC for fish (direct effects to aquatic-phase CRLF).

Table 9. Summary of NAWQA diazinon monitoring data from specific CA sites with agricultural watersheds.

Site Name	Site ID	County	Mean* (µg/L)	S.D. (µg/L)	90th % (µg/L)	Max (µg/L)	% Detects	Total # Samples	Sample Dates
HIGHLINE CN SPILL NR HILMAR CA	372323120481700	Merced	0.044	0.045	0.119	**0.126**	88.2	17	2000-2004
MUD SLOUGH NR GUSTINE CA	11262900	Merced	0.029	0.074	0.045	**0.325**	86.4	22	2001
NEWMAN WASTEWAY A HWY 33 NR GUSTINE CA	371903120585400	Merced	0.051	0.051	0.116	**0.154**	90.9	11	2000-2001
SALT SLOUGH A HWY 165 NR STEVINSON CA	11261100	Merced	0.020	0.041	0.042	**0.184**	90.9	22	2001
DEL PUERTO C AT VINEYARD ROAD NR PATTERSON	11274653	Stanislaus	0.101	0.238	0.231	**1.060**	94.1	34	2000-2001
DRY C A CLAUS RD BRIDGE A MODESTO CA	373925120550701	Stanislaus	0.050	0.094	0.105	**0.347**	92.9	14	2000
HARDING DRAIN A CARPENTER RD NR PATTERSON CA	11274560	Stanislaus	0.039	0.018	0.061	**0.069**	90.9	11	2000-2001
ORESTIMBA CR AT RIVER RD NR CROWS LANDING CA	11274538	Stanislaus	0.046	0.102	0.086	**0.572**	83.2	131	2000-2004
SACRAMENTO SLOUGH NR KNIGHTS LANDING CA	11391100	Sutter	0.023	0.026	0.045	**0.106**	51.5	33	2001-2004

*Includes detections of diazinon in samples that were quantified and estimated.

3.1.1.2.2. Urban landcovers

Several studies throughout the U.S. have reported declines in surface water concentrations of diazinon in urban and mixed-use watersheds after residential use reductions beginning in 2000 (USGS 2006; Banks *et al*. 2005; Embrey and Moran 2004). Although residential use of existing stocks of diazinon are still permitted, it is likely that the overall use of diazinon in urban areas in California has declined, resulting in lower concentrations of diazinon in runoff from these areas. This would be consistent with data trends observed at urban sites in other parts of the US.

A cursory analysis of the available NAWQA data relevant to surface waters with urban California watersheds seems to support the idea that diazinon concentrations are generally decreasing in waters receiving runoff from urban areas. When considering yearly data relevant to 1995-2005 for all waters in California, mean and maximum measured concentrations of diazinon generally declined over the time period (**Table 10**), although there is no apparent trend in the frequency of detection.

Table 10. Measured concentrations of diazinon in surface waters with urban watersheds.

Stats	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of Detections	16	2	24	5	11	26	29	15	13	15	18
% Detects	100.0	100.0	100.0	83.3	52.4	74.3	93.5	88.2	81.3	78.9	100.0
Maximum concentration (µg/L)	**1.100**	**0.337**	**1.380**	**0.420**	**0.198**	**0.774**	**0.947**	**0.430**	**0.588**	**0.218**	**0.085**
Average Concentration (µg/L)	0.640	0.277	0.370	0.223	0.044	0.106	**0.342**	**0.141**	**0.147**	**0.056**	**0.035**
Standard Deviation	0.274	0.086	0.285	0.150	0.060	0.204	0.326	0.142	0.164	0.059	0.021
90th percentile concentration (µg/L)	0.915	0.325	0.673	0.362	0.095	0.336	0.773	0.347	0.306	0.128	0.068

From 1995-2005, a total of 204 samples were collected from 14 different surface waters with watersheds composed of urban watersheds. Two of these sample sites, ID#11447360, located in Sacramento County (**Figure 11**), and ID#11060400, located in San Bernardino county (**Figure 12**), contained sufficient samples over time (89 and 71, respectively) to present diazinon concentrations before and during the phase-out of residential uses of diazinon. An analysis of these data indicate a weak (*i.e.* R^2 values <0.4) downward trend over time in diazinon concentrations in surface waters receiving runoff from urban areas. Uncertainties in these analyses come from a lack of uniform sampling time periods, different use patterns over time in residential areas and different precipitation patterns over time. Data described in **Table 10** and **Figures 11 and 12** are not time-weighted.

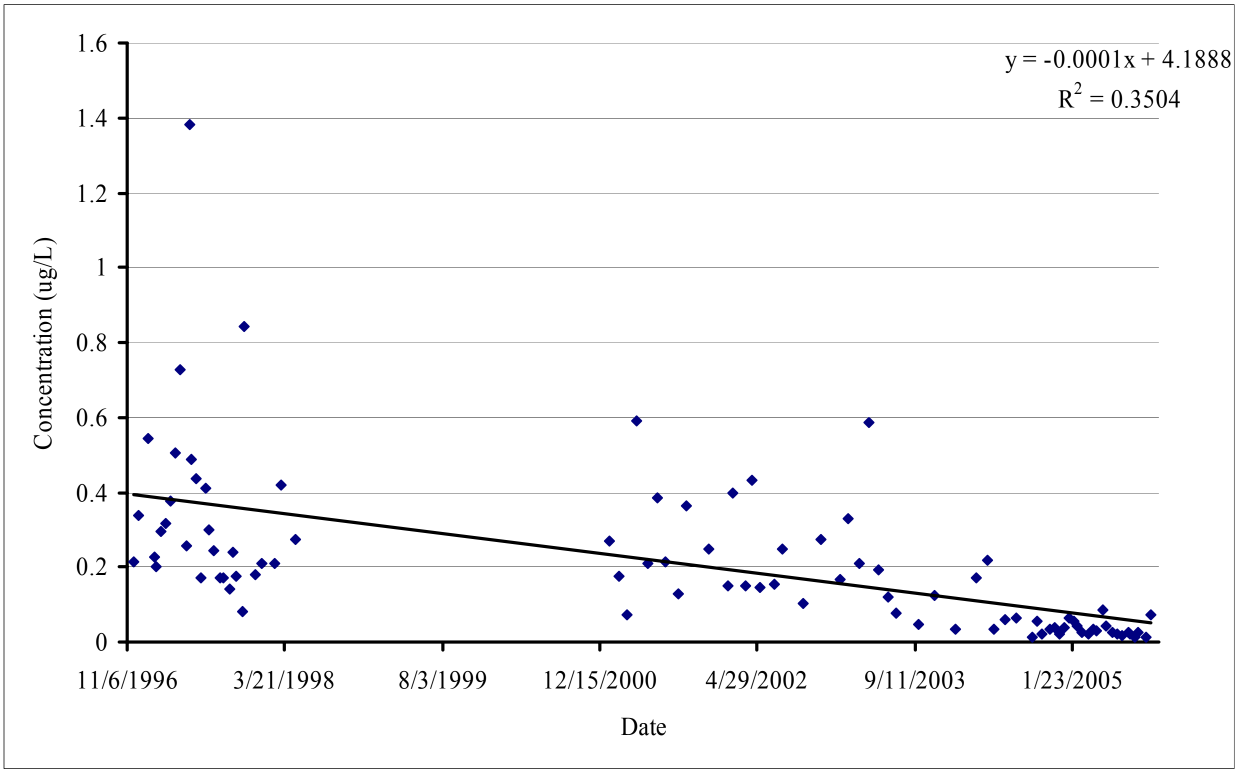


Figure 11. Diazinon concentrations over time at surface water NAWQA site 11447360 (located in Sacramento County), which has urban watershed.

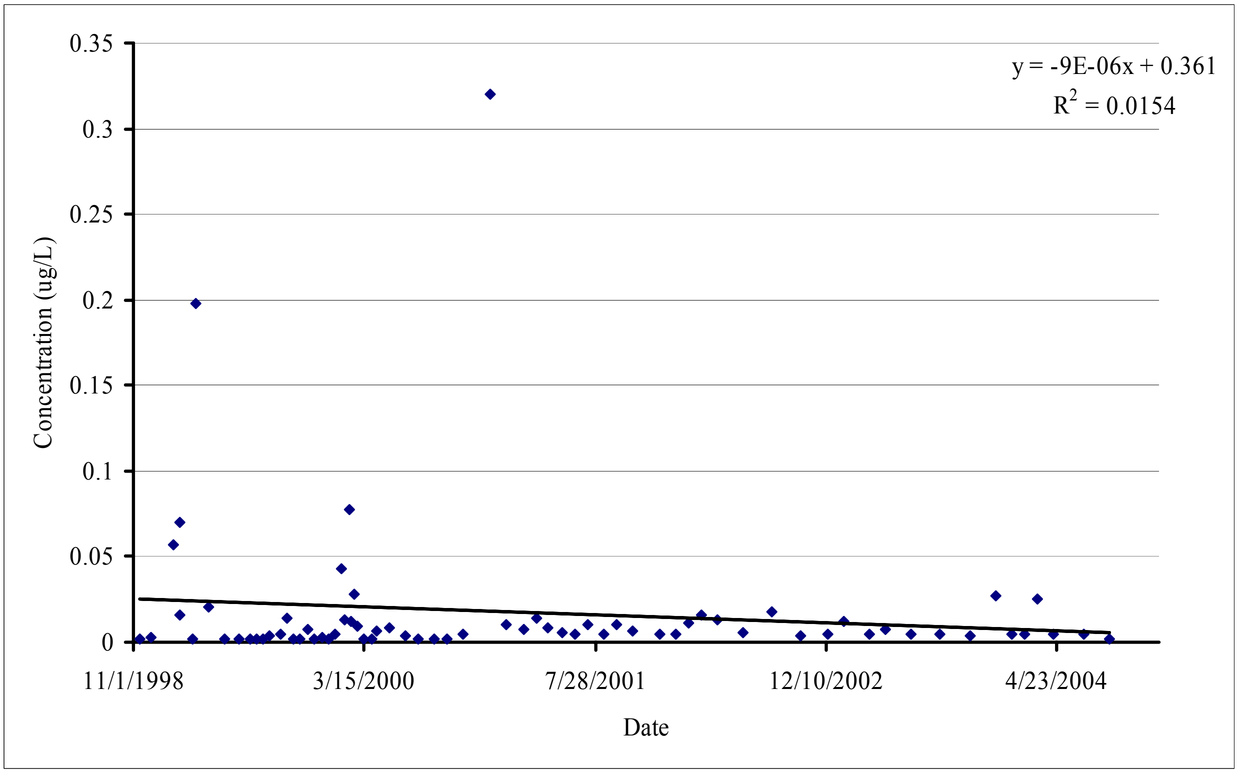


Figure 12. Diazinon concentrations over time at surface water NAWQA site 11060400 (located in San Bernardino County), which has urban watershed.

3.1.1.3. USGS monitoring of California surface waters

Since 2000, USGS, in cooperation with the CDPR, has published several reports involving monitoring of California water bodies for diazinon. These studies, which are briefly described below, have included monitoring in the San Joaquin River Basin and the Sacramento River and its tributaries. Earlier results of these studies were summarized in the diazinon TRED.

3.1.1.3.1. San Joaquin River Basin

The San Joaquin River Basin drains an area in Sierra Nevada and the San Joaquin Valley, and the Coast. Relevant diazinon use for this basin includes dormant season applications (December – February) to stone fruits and almonds (Kratzer et al. 2002) and field crops and orchards in the spring and summer (Domagalski and Munday 2003).

In January-February 2000 and again in January-February 2001, USGS sampled several sites within the San Joaquin River Basin, on a weekly basis during non-storm periods, and more frequently during storm events. These sampling periods coincided with dormant season applications of diazinon to orchards. In 2000, 13 major river and minor tributary sites were sampled, while in 2001, 8 sites were sampled, with some overlap between the sites from one year to the next. During both time periods and for the majority of the sample sites, the highest concentrations of diazinon were observed during storm runoff events. In the first study, diazinon was detected in 82-100% of samples per site with a maximum observed concentration of 0.834 µg/L for all sites. In the second study, diazinon was detected in 95-100% of samples per site with a maximum observed concentration of 0.435 µg/L for all sites (Kratzer et al. 2002; Zamora et al. 2003)

During April to August 2001, 12 sites within the San Joaquin Valley were sampled weekly for monitoring of diazinon (Domagalski and Munday 2003). Some of the sites sampled during this study overlapped with those studied in previous USGS studies (Kratzer *et al.* 2002; Zamora *et al.* 2003). During April-August, diazinon was detected in 30-100% of samples depending upon the site. Median concentrations at the sample sites ranged <0.005 to 0.011 µg/L, with 90 percent of all measured concentrations <0.06 µg/L. The maximum measured concentration for all sites was 0.325 µg/L (Domagalski and Munday 2003).

3.1.1.3.2. Sacramento River

The Sacramento River and its tributaries drain land in northern California. Two studies were completed by the USGS to monitor water concentrations of diazinon resulting from dormant season applications of diazinon to orchards. The first study was targeted to monitor diazinon concentrations in runoff resulting from three winter storms occurred during January 30-February 25, 2000. Sites (n=17) on the Sacramento River and its tributaries were sampled for 5 consecutive days for each of the 3 storms. The peak measured concentration of diazinon was 2.89 µg/L, while the median (n=138) was 0.044 µg/L. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural or urban landcovers (Dileanis *et al*. 2002). The second study was targeted to monitor diazinon concentrations in runoff resulting from 2 winter storms during January 24-February 14, 2001. These storms occurred after dormant spray applications of diazinon to orchards located within the Sacramento Valley. Different sized tributaries as well as portions of the Sacramento River were sampled, representing 21 different sites receiving runoff from areas with both agricultural and urban landcovers. The maximum observed concentration of diazinon was 1.38 µg/L, with median concentrations for the first and second storms of 0.055 and 0.026 µg/L, respectively. Observed diazinon concentrations were greatest in samples collected from small streams draining areas with agricultural landcovers (Dileanis *et al*. 2003).

3.1.1.4. California Department of Pesticide Regulation Surface Water Database

CDPR maintains a database of monitoring data of pesticides in CA surface waters. The sampled water bodies include rivers, creeks, urban streams, agricultural drains, the San Francisco Bay delta region and storm water runoff from urban areas. The database contains data from 51 different studies by federal (including the USGS NAWQA program), state and local agencies as well as groups from private industry and environmental interests. Data are available from 1990-2005 for 27 counties for several pesticides and their degradates. Data for diazinon, as well as diazoxon are included in this database (CDPR 2007). For the purpose of this assessment, diazinon monitoring data from 2000-2005 were accessed from the CDPR database and are discussed below. Available diazoxon data were collected from 1991-1995 and are not discussed further in this assessment.

From 2000-2005, 2037 samples from CA surface waters were analyzed for diazinon. Of these, diazinon was detected in 52%, with a maximum concentration of 15.5 µg/L. These samples included 121 different sites from 18 counties; including counties where CRLF core areas and critical habitat are located. When considering all samples analyzed during this time period (including non-detections), diazinon was detected at concentrations (*i.e.*, >0.0105 µg/L) sufficient to exceed the listed species LOC for aquatic invertebrates (indirect effects to CRLF forage base) in 868 samples, which represents 43% of samples. Diazinon was detected at concentrations >4.5µg/L, which are sufficient to exceed the acute to listed species LOC (RQ≥0.05) for freshwater fish (direct effects on the aquatic-phase CRLF) in 5 samples, which represents 0.2% of the total samples (**Figure 13**).

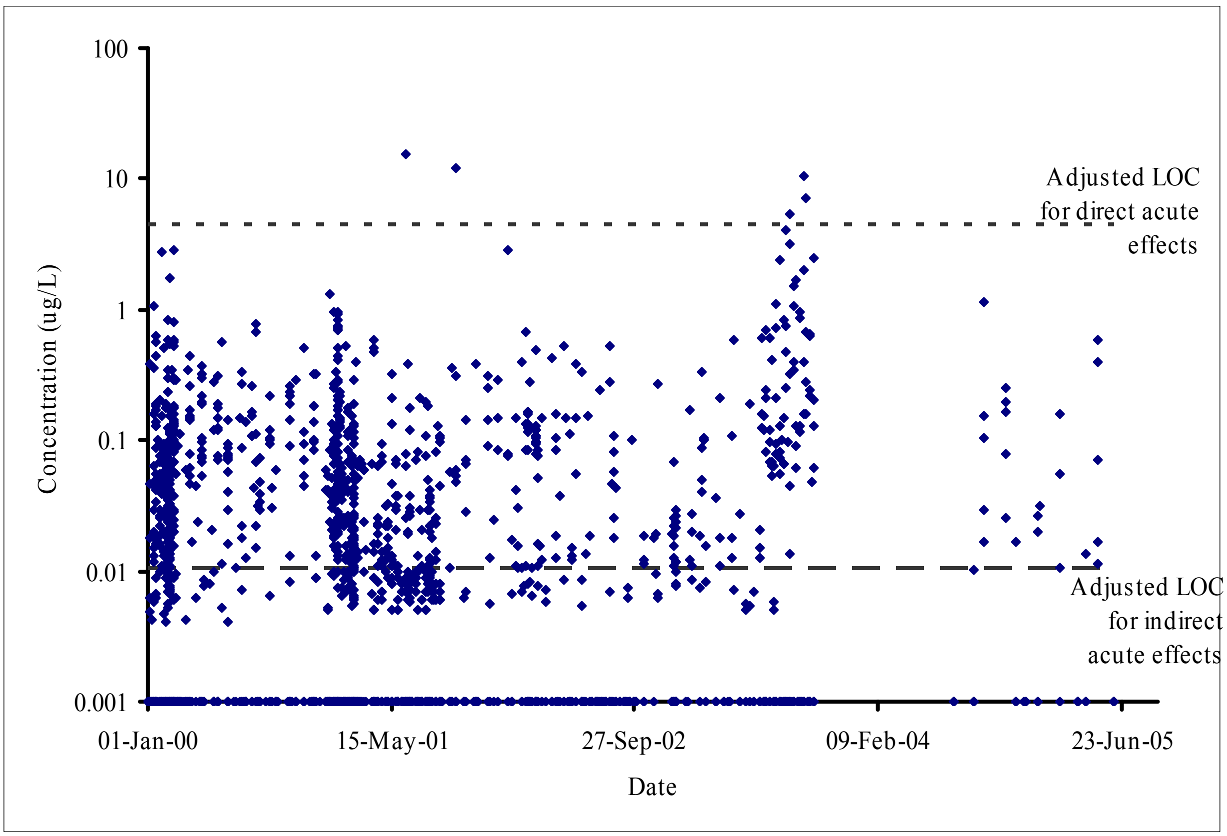


Figure 13. CDPR reported concentrations of diazinon in surface waters in CA (includes detections and non-detections, which are represented as 0.001). Bottom dashed line represents the concentration that would result in an exceedance of the listed species LOC for aquatic invertebrates (indirect effects to forage base of CRLF); upper dotted line represents the concentration that would exceed the listed species LOC for fish (direct effects to aquatic-phase CRLF).

Some data reported in this database are also reported by USGS in NAWQA; therefore, there is some overlap between these two data sets. Unlike, NAWQA data, the land use (*e.g.* agriculture, urban) associated with the watershed of the sampled surface waters is not defined in the CDPR database; therefore, the available data do not allow for a link of the general use pattern and the individual data. This is particularly relevant to diazinon, given use changes associated with cancellation of residential uses of diazinon as well as label modifications for a number of agricultural uses made since 2000. Therefore, it is not possible to distinguish between diazinon detections resulting from residential uses and those resulting from agricultural uses.

3.1.1.5. TMDL monitoring in California's Central Valley

Additional water monitoring data are available in a study entitled "*TMDL Monitoring of Pesticides in California's Central Valley Waterways. John Muir Institute for the Environment, University of California at Davis.*" This study was conducted by the Aquatic Ecosystems Laboratory of the John Muir Institute at UC-Davis under a contract from the Regional Water Quality Control Board, Central Valley Region (Calanchine 2005). The purpose of the study was "to monitor selected sites in the Sacramento River Basin, the eastern Sacramento-San Joaquin Delta tributary area, and the San Joaquin River Basin over two storm events during the winter of 2005-06 to further characterize and define sources of diazinon, chlorpyrifos, and other pesticides that may cause surface water contamination and toxic conditions to aquatic life." In part, the results of the study would be used by the study sponsor to support development of Total Maximum Daily Loads (TMDLs) for pesticides in Central Valley watersheds.

Locations for sample collection were taken from three general regions in the Sacramento-San Joaquin Watershed, the Sacramento River and its tributaries, the San Joaquin and its tributaries, and the Sacramento-San Joaquin Delta. The sites in the Sacramento River Watershed were located in Sutter, Butte, and Sacramento Counties, those for the Delta in San Joaquin and those in the San Joaquin River Watershed are in Stanislaus and Merced Counties. The two sites along the Sacramento River were selected to assess progress in meeting water quality objectives for the basin. Other sites were chosen based on documented pesticide use in the watershed, pesticide-caused toxicity observed in the stream or river, and the inclusion of targeted pesticide on a 303(d) impaired water body lists. Data were reported for concentrations of diazinon at 12 sites. The detection frequency ranged 50-100% and 6 of the 12 sites had detections over 0.1 µg/L (**Table 11**).

Table 11. Results from monitoring for diazinon in the Central Valley of California in the winter of 2006 (John Muir Institute, 2006).

Site	Number of Samples	Percent Detections	Maximum Concentration (µg/L)
Sacramento River Watershed Sites			
Angel Canal/Commanche Creek	4	100	0.360
Gilsizer Slough	4	100	0.778
Live Oak Slough	4	100	0.738
Morrison Slough	4	100	0.294
Sacramento River (Alamar)	9	56	0.009
Sacramento River (Freeport)	9	56	0.003
Delta Sites			
Littlejohn Creek	4	100	0.044
Lone Tree Creek	4	100	0.246
Mormon Sough	4	50	0.014
Pixley Slough	4	100	0.116
San Joaquin River Watershed Sites			
Del Puerto Creek	4	50	0.015
Orestimba Creek	2	50	0.009
NR – not reported			

Available county level pesticide use data for California (CDPR 2007a) were considered to understand the predominant uses of diazinon in the counties sampled by the John Muir Institute. Data for 2006 are unavailable at this time. Data for 2005 provide information on the extent of use in the counties where monitoring data were collected in this study. All six counties in the study show considerable usage of diazinon during January and February, which is considered the dormant spray season as the trees are leafless at this time of year. In addition to the crops identified in **Table 12**, there were small amounts of diazinon applied in these 6 counties to apricots, pears, and walnuts (total <350 lbs). Other diazinon uses in these 6 counties include: 3 lb used for 'landscape maintenance', 24 lb used in green houses, 33 lb for outdoor nursery plants, and 91 lbs used around structures. This suggests that the occurrence of diazinon in this monitoring study is associated with the dormant spray application to deciduous orchard crops.

Table 12. Major uses of diazinon in January and February in 6 counties in California (CDPR 2007).

County	Almonds	Apples	Cherries	Peaches and nectarines	Prunes and plums
	pounds				
Butte	2409	4510	961	1822	2177
Merced	1218	0	16	16	83
Sacramento	0	4566	116	20	16
San Joaquin	12022	8	1408	0	4
Sutter	14080	0	102	1666	184
Stanislaus	12	0	0	10687	14396

3.1.2. Modeling Approach

As stated above, the Tier II models used to calculate aquatic EECs are PRZM and EXAMS. For this modeling effort, PRZM scenarios designed to represent different crops and geographic areas of CA are used in conjunction with the standard pond environment in EXAMS. Use-specific and chemical-specific parameters for the Pe4 shell as well as PRZM scenarios are described below.

An example of an output file from PRZM/EXAMS, which is represented by modeling of 2 aerial applications of diazinon per year to lettuce, is in **Appendix B**.

3.1.2.1. Input Parameters

3.1.2.1.1. Chemical specific parameters

The appropriate chemical-specific PRZM input parameters are selected from reviewed environmental fate data submitted by the registrant (**Table 2**) and in accordance with EFED water model input parameter selection guidance (U.S. EPA 2002). The input parameters selected are similar to those used in the 2002 diazinon IRED (U.S. EPA, 2006). No new environmental fate data were incorporated into this assessment. A summary of the chemical specific model inputs used in this assessment are provided in **Table 13**.

Since the coefficient of variation for the organic carbon partition coefficient, *i.e.*, $K_{oc.}$ (CV = 25) is less than the coefficient of variation for K_f (CV = 159) in the submitted study, the average K_{OC} of 616 L/kg_{OC} was used to represent binding to soil and sediment.

There are two studies available to estimate the aerobic soil metabolism rate for diazinon, each on one soil. Because the half-lives from these studies are similar (37.4 days and 38.0 days), the upper confidence bound on the mean is similar as well (38.7 days), as calculated according to current EFED guidance for selecting water model input parameters (U.S. EPA 2002).

Table 13. PRZM/EXAMS Input Parameters.

Input Parameter	Value	Source
Koc (L/kg_{OC})	616	MRID 00118032
Henry's Law Constant (atm-m^3/mol)	1.40×10^{-6}	U.S. EPA 1988
Hydrolysis (days)	pH 5: 12 pH 7: 138 pH 9: 77	MRID 40931101
Aerobic Soil Metabolism Half-life (days)	38.7	MRID 40028701 MRID 44746001
Aerobic Aquatic Metabolism Half-life (days)	77.4	No data available. Assume 2x value for aerobic soil metabolism (USEPA 2002)
Anaerobic Aquatic Metabolism Half-life (days)	0	No data available. Assume stable (USEPA 2002)
Aqueous Photolysis Half-life (days)	37	MRID 40863401
Vapor pressure (torr)	1.40×10^{-4}	U.S. EPA, 1988
Solubility in water (mg/L @ pH 7, 20^{o}C)	400	USEPA 1988, solubility value x10 (USEPA 2002)
Molecular Wt. (g/mol)	304.3	Product chemistry

3.1.2.1.2. Use-specific parameters

Use specific parameters include application methods and rates (**Table 3**). Application methods, maximum rates per application and maximum number of applications per year are based on current label directions (**Table 14**).

According to the label, aerial applications are only permitted for use of diazinon on lettuce. Application efficiency and spray drift were chosen as 0.95 and 0.05, respectively, according to input parameter guidance (USEPA 2002). For all other uses, applications are permitted by ground methods only. Default values for application efficiency and spray drift of 0.99 and 0.01, respectively, were chosen to represent ground applications.

Table 14. Use specific parameters used to model aquatic EECs using PRZM/EXAMS. In cases where multiple applications were allowed per year (*e.g.* blueberries), single applications were also modeled.

Uses	Application type	# of apps/ year	Max rate / App (kg a.i./ha)	CAM	IPSCND	Application date	Application Interval (days)
Almonds	foliar	1	3.36	2	1	March 15	NA
	dormant	1	3.36	2	1	Dec 15	NA
Blueberries	foliar	2	1.12	2	1	April 8	7
	foliar	1	1.12	2	1	April 8	NA
	fire ant	1	1.12	1	NA	April 8	NA
Caneberries	foliar	1	2.24	2	1	April 8	NA
Cole crops	soil incorporation	1	4.48	4	NA	Dec 15	NA
Fig	foliar	1	0.56	2	1	March 15	NA
Leafy vegetables	soil incorporation	1	4.48	4	NA	Jan 25	NA
Lettuce	Foliar*	2	2.24	2	1	Jan 25	30
	Soil incorporation*	1	2.24	4	NA	Jan 25	NA
	Foliar*	1	2.24	2	1	Feb 25	NA
Melons	Foliar	2	4.48	2	1	May 1	30
	soil incorporation	1	4.48	4	NA	May 1	NA
	foliar	1	4.48	2	1	May 30	NA
Outdoor Ornamentals	foliar	26	1.12	2	2	Jan 2	14
	foliar	1	1.12	2	2	Jan 2	NA
Root crops	soil incorporation	1	4.48	4	NA	Dec 26	NA
Row crops	soil incorporation	1	4.48	4	NA	Dec 15	NA
Strawberries	foliar	2	1.12	2	1	Jan 1	30
	soil incorporation	1	1.12	4	NA	Dec 15	NA
	foliar	1	1.12	2	1	Jan 1	NA
Tomatoes	soil incorporation	1	4.48	4	NA	Feb 14	NA
Tree fruit	1 foliar + 1 dormant	2	2.24	2	1	March 15	270
	1 foliar	1	2.24	2	1	March 15	NA
	1 dormant	1	2.24	2	1	Dec 15	NA
Tuber crops	soil incorporation	1	4.48	4	NA	Feb 1	NA

NA = not applicable
*Aerial application.

Number of Applications/Year

For the majority of diazinon uses (almond, caneberries, colecrops, fig, leafy vegetables, root crops, row crops, tomatoes, tuber crops), applications are allowed only once a year.

Applications to blueberries, melons, strawberries, and tree fruit are allowed up to twice a year.

Applications to lettuce are allowed up to twice a season. Given that more than one crop of lettuce can be harvested within a year, there is potential for more than two applications of diazinon to lettuce within a year. Due to limitations of the PRZM scenario for lettuce, exposure from only one season was modeled.

Applications to ornamentals are allowed once a season. The number of seasons possible per year is unknown. A conservative estimate of 26 seasons (1 season every 14 days) was utilized for modeling the annual applications of diazinon to outdoor ornamentals.

In cases where multiple applications of diazinon were possible for a crop, single applications were modeled to gain understanding of the aquatic exposure of diazinon originating from single applications.

Maximum Application Rate per Application

Maximum single application rates were determined by currently active Section 3 and special local needs labels for diazinon.

CAM

In PRZM, application methods are defined by the CAM (Chemical Application Method) values; CAM values of 1 are used to represent applications to soil with no incorporation, such as would be done when treating for fire ants. A CAM value of 2 is used to represent foliar applications; and a CAM value of 4 is used to represent applications to soil, with incorporation. In cases where CAM 4 is modeled, a default value of 4 cm is used as the incorporation depth. Labels suggest a range of incorporation depths for different crops and pests, ranging 1 to 8 inches (2.5-20 cm).

In cases were two different types of applications allowed per year, simplifying assumptions are made based on model (Pe4 shell) limitations. This generally involved assigning the same CAM value to represent two different application methods. This is relevant to modeling associated with lettuce, melons, and strawberries. In these cases, within one year, one soil application with incorporation is allowed along with one foliar application. In order to model the exposure resulting from multiple applications, a CAM of 2 is chosen to represent foliar application. This is also the case with modeling exposures resulting from diazinon applications to blueberries, where applications include one foliar and one soil application to treat fire ants.

IPSCND

In cases where CAM 2 is modeled, it is necessary to identify an IPSCND value, which represents the deposition of diazinon in the post-season (IPSCND). For this modeling effort, an IPSCND of 1 is chosen to accompany CAM 2 selections. This value represents conversion of diazinon remaining on foliage to surface application to the top soil layer. The exception to this is applications of diazinon to orchard crops, for which an IPSNCD of 2 is chosen to represent the removal of pesticide on foliage after harvest. In selecting this parameter value, it is assumed that "harvest" of ornamental crops represents removal of the plants from the nursery, therefore, pesticide contained on the plant's foliage would be removed with the plant.

Application Dates

Application dates are not specified on the product labels. For uses involving soil incorporation, label instructions indicate that diazinon should be applied to a field before planting the crop. Therefore, application dates for these uses were chosen as 15 days before the emergence date programmed in the appropriate PRZM scenario.

For applications of diazinon to almond, fig and tree fruit crops, application dates for foliar applications were chosen as March 15, to represent typical application times in CA for these uses. Since dormant season applications are also allowed for almonds, an application date of December 15 was modeled separately for dormant season applications to almonds.

For foliar applications of diazinon to blueberries and caneberries, the date was chosen as 1 week after the maturity date of the crop, according to the appropriate PRZM file. The application date for the ornamental use was chosen arbitrarily since year round applications were modeled.

Application Interval

For applications that are potentially made to a crop multiple times a year, the label does not specify application intervals. Therefore, it is necessary to determine appropriate application intervals for these crops.

For blueberries, the application interval of 7 days is chosen because it is a reasonable application interval between the two different intended uses of diazinon (*e.g.* 1 foliar application, and 1 to treat fire ants).

For lettuce and melons, the application interval is selected to correspond to the types of application methods being modeled. Since the first application is intended to be made before planting (15 days before emergence), and the second is intended to be made to leaves (15 days after emergence), a 30 day interval is assumed to capture that interval.

For outdoor ornamentals, it is assumed that there could be a new crop of plants every 14 days, therefore, a new application of diazinon could be made every 14 days.

For applications of diazinon to tree fruit, the label allows for 1 foliar application and one dormant season per year. It is assumed that the foliar applications would take place on approximately March 15, while the dormant season applications would take place on approximately December 15. In order to account for these two days, the initial application was modeled as March 15, while the application interval was set to 270 days so that the dormant season application would be modeled in December.

3.1.2.2. PRZM scenarios

Several standard PRZM scenarios already exist for California, including: CAlettuce, CAnursery, CAalmond, CAonion, CAtomato, and CAfruit. Several of the scenarios were developed specifically for the uses being modeled for this assessment, including: CAcolecrop, CAmelon, CArowcrop, CAwinegrapes, CAstrawberry(nonplastic), and CApotato. PRZM scenarios used to model aquatic exposures resulting from applications of specific uses are identified in **Table 15.** In cases where a scenario does not exist for a specific use, it is necessary to assign a surrogate scenario. Those surrogates are assigned to be most representative of the use being considered. Justifications for assignments of surrogates are defined below. In all cases, scenarios are run without consideration of irrigation.

Table 15. PRZM scenario assignments according to uses of diazinon.

PRZM scenario	Uses
CA colecrop	Cole crops (Broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens)
CA lettuce	Lettuce and Leafy vegetables (endive, spinach)
CA melon	Melons (cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons)
CA almond	Almonds
CA nursery	outdoor ornamentals
CA onion	Root crops (onion, radishes)
CA rowcrop	Row crops (carrots, beans, peppers (bell and chili), peas (succulent), beets (red))
CA wine grapes	caneberries, blueberries
CA strawberry (nonplastic)	strawberries
CA tomato	tomatoes
CA fruit	Tree fruit (apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes)
CA potato	Tuber crops (rutabagas, sweet potatoes)

Almond scenario

This scenario is intended to represent almond production in CA and is therefore, directly relevant to this use.

Cole crop scenario

This scenario is intended to represent cole crop production, specifically broccoli, in the Central California coast and Coastal Valley Mountin range. Therefore, exposures resulting from applications of diazinon to broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale and mustard greens are modeled using this scenario.

Lettuce scenario

This scenario is intended to represent lettuce, which is a leafy vegetable. It is assumed that this scenario is representative of other leafy vegetables, including spinach and endive.

Melon scenario

This scenario is intended to represent applications of pesticides to melons in CA and is therefore, directly relevant to this use.

Nursery scenario

This scenario is intended to represent applications of pesticides in outdoor nurseries in CA and is therefore, directly relevant to this use.

Onion scenario

This scenario is intended to represent an onion field in Kern County. Therefore, it is relevant to modeling diazinon applications to onion crops. In addition, this scenario is used to represent radishes since it represents a root crop similar to onion. The two crops are potentially grown in similar areas.

Row crop scenario

This scenario is intended to represent production of carrots, beans, peppers and other crops in CA, and is therefore, directly relevant to these uses. Beets and peas are considered row crops and are classified in this category. Therefore, this scenario is used to represent fields growing carrots, beans, peppers (bell and chili), peas (succulent) and beets (red).

Wine grapes scenario

According to NASS, caneberries are mostly grown in Santa Cruz County. Blueberries are grown in the costal valley. This scenario is intended to represent a field in Northern Costal CA (Sonoma, Napa, Lake and Mendocino Counties). The meteorological station for this scenario is located in San Francisco. The meteorological station and the soil are in close proximity to Santa Cruz County (which is to the south) and overlap in range with the region of blueberry cultivation.

Strawberry scenario

This scenario is intended to represent applications of pesticides to strawberries (non-plastic) in CA and is therefore, directly relevant to this use.

Tomato scenario

This scenario is intended to represent applications of pesticides to tomatoes in CA and is therefore, directly relevant to this use.

Fruit scenario

The CA fruit scenario represents an orchard in Fresno County, which is located in the Central Valley. This scenario is intended to represent non-citrus fruit, including peaches, plums, prunes, pears and apples. According to the USDA crop profile for figs in CA, The San Joaquin Valley (Madera, Merced, and Fresno Counties) is the major fig-producing area in the state. Therefore, this scenario is used to represent applications of diazinon to tree fruit (apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes) and figs.

Potato scenario

This scenario is used to represent cultivation of sweet potatoes and rutabagas, referred to in this assessment as "tuber crops." The sweet potato use is relevant to a SLN for Merced County only. The CA potato scenario is representative of a field in Kern County, which is to the south of Merced Co. No NASS data have been located to clarify which counties in CA grow rutabagas. Therefore, it is assumed that this tuber crop would grow under similar conditions as the potato.

3.1.3. Aquatic Modeling Results

PRZM/EXAMS EECs representing 1-in-10 year peak, 21-day, and 60-day concentrations of diazinon in the aquatic environment are located in **Table 16**.

Table 16. Aquatic EECs from PRZM/EXAMS modeling for maximum application rates of diazinon. EECs are based on the appropriate PRZM scenario and the standard EXAMS pond.

Uses	Application # and type	Peak EEC (µg/L)	21-day EEC (µg/L)	60 -day EEC (µg/L)
Almonds	1 dormant	15.63	11.89	8.79
	1 foliar	9.10	7.27	5.38
Blueberries	2 foliar	2.61	2.14	1.52
	1 foliar	1.49	1.20	0.85
	1 fire ant	1.43	1.18	0.84
Caneberries	1 foliar	2.98	2.40	1.70
Cole crops[1]	1 soil incorporation	24.10	19.66	16.95
Fig	1 foliar	0.63	0.52	0.39
Leafy vegetables[2]	1 soil incorporation	54.74	46.67	35.22
Lettuce	2 aerial foliar	59.48	51.26	42.81
	1 soil incorporation	27.37	23.34	17.61
	1 aerial foliar	30.85	24.98	18.56
Melons [3]	2 foliar	4.92	3.83	3.31
	1 soil incorporation	3.32	2.59	1.94
	1 foliar	2.48	1.91	1.31
Outdoor ornamentals	26 foliar	49.90	40.93	33.94
	1 foliar	6.79	5.53	4.49
Root crops [4]	1 soil incorporation	12.10	8.43	6.55
Row crops [5]	1 soil incorporation	16.32	13.27	10.08
Strawberries	2 foliar	26.53	23.48	18.01
	1 soil incorporation	11.23	8.76	6.69
	1 foliar	21.41	18.12	13.57
Tomatoes	1 soil incorporation	10.31	8.77	6.58
Tree fruit [6]	1 foliar + 1 dormant	6.70	5.62	3.28
	1 dormant	7.16	6.10	4.19
	1 foliar	2.53	2.08	1.55
Tuber crops [7]	1 soil incorporation	11.40	9.21	6.76

[1] broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens
[2] spinach, endive
[3] cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons
[4] onion, radishes
[5] carrots, beans, peppers (bell and chili), peas (succulent), beets (red)
[6] apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes
[7] rutabagas, sweet potatoes

3.2. Terrestrial Exposure Assessment

3.2.1. Exposure to Plants

TerrPlant is used to calculate EECs for non-target plant species inhabiting dry and semi-aquatic areas. Parameter values for application rate, drift assumption and incorporation depth are based upon the use and related application method (**Table 17**). A runoff value of 0.2 is utilized based on diazinon's solubility, which is classified by TerrPlant as 10-100 mg/L. For ground application methods, a drift assumption of 1% is selected. A drift assumption of 5 % is selected to represent aerial applications to lettuce and air blast applications to orchard crops, including almond and tree fruit crops. For diazinon applications involving soil incorporation, 1.6 cm is used to represent incorporation depth. EECs relevant to terrestrial plants consider pesticide concentrations in drift and in runoff. These EECs are listed by use in **Table 17**. An example output from TerrPlant v.1.2.2 is available in **Appendix C**.

Table 17. TerrPlant inputs and resulting EECs for plants inhabiting dry and semi-aquatic areas exposed to diazinon through runoff and drift.

Use	Application rate (lbs a.i./A)	Application method	Drift Value (%)	Spray drift EEC (lbs a.i./A)	Dry area EEC (lbs a.i./A)	Semi-aquatic area EEC (lbs a.i./A)
Almonds	3	Foliar/dormant	0.05	0.15	0.21	0.75
Blueberries	1	Foliar/ground (fire ant)	0.01	0.01	0.03	0.21
Caneberries	2	Foliar	0.01	0.02	0.06	0.42
Colecrops	4	Soil incorporation	0.01	0.04	0.09	0.54
Fig	0.5	Foliar	0.05	0.025	0.035	0.125
Leafy vegetables	4	Soil incorporation	0.01	0.04	0.09	0.54
lettuce	2	Soil incorporation	0.05	0.1	0.125	0.35
	2	Foliar	0.05	0.1	0.14	0.5
Melons	4	foliar	0.01	0.04	0.12	0.84
	4	Soil incorporation	0.01	0.04	0.09	0.54
outdoor ornamentals	1	foliar	0.01	0.01	0.03	0.21
Root crops	4	Soil incorporation	0.01	0.04	0.09	0.54
Row crops	4	Soil incorporation	0.01	0.04	0.09	0.54
strawberries	1	Foliar	0.01	0.01	0.03	0.21
	1	Soil incorporation	0.01	0.01	0.0225	0.135
Tomatoes	4	Soil incorporation	0.01	0.04	0.09	0.54
Tree fruit	2	foliar	0.05	0.1	0.14	0.5
Tuber crops	4	Soil incorporation	0.01	0.04	0.09	0.54

3.2.2. Exposures to animals

3.2.2.1. Modeling Approach

T-REX is used to calculate dietary and dose-based EECs of diazinon for the CRLF and its potential prey (*e.g.* small mammals) inhabiting terrestrial areas. EECs used to represent CRLF are also used to represent exposure values for frogs serving as potential prey of CRLF adults. T-REX simulates a 1-year time period. A foliar dissipation half-life of 5.3 days is used based on data reported by Willis and McDowell (1987). The Mineau scaling factor of 0.63 is used to improve interspecies extrapolation of dose-based toxicity data for birds (surrogate for the CRLF) exposed to diazinon (Mineau et al. 1996). Use specific input values, including number of applications, application rate and application interval are located in **Table 18**. An example output from T-REX v.1.3.1 is available in **Appendix D**.

Table 18. Input parameters for foliar applications used to derive terrestrial EECs for diazinon with T-REX. Applications made by ground incorporation are not modeled using T-REX.

Use	Number of applications	Application rate (lbs a.i./A)
Almonds	1	3
Blueberries	1	1
Caneberries	1	2
Fig	1	0.5
lettuce	1	2
Melons	1	4
outdoor ornamentals	26*	1
	1	1
strawberries	1	1
Tree fruit	1	2

*Application interval of 14 days.

Only foliar applications are modeled, since T-REX is not appropriate for modeling soil applications with incorporation. Therefore, several uses of diazinon in California are not modeled here, including applications to colecrops, leafy vegetables, root crops, row crops, tomatoes and tuber crops. At this time, exposures to the CRLF and its prey in the terrestrial habitat are not assessed for these uses. Although there are number of diazinon uses where the chemical is applied to bare ground with soil incorporation, these uses were not evaluated for risks to terrestrial-phase CRLF since it is unlikely that the animals would be foraging in open fields devoid of cover. Therefore, exposure from these uses is expected to be *deminimus*.

For nursery operations, labels indicate a maximum application rate of 1 lb a.i./A for every crop. Since it is possible to have more than one crop of ornamental plants at a nursery operation, it is possible to have multiple applications of 1 lb a.i./A in one year. In order to represent the exposure of diazinon originating from a year of applications of diazinon to ornamental crops at an outdoor nursery, it is assumed that a new crop of ornamental plants is present at a nursery operation every 14 days, which represents the application interval. Therefore, the total number of applications possible in one year is 26. In order to understand the exposure resulting from a single application to outdoor nursery stock, a single application is also modeled.

According to current labels, it is possible to have 2 applications per year to fruit crops: one foliar application and one dormant application. Based on the expected temporal interval between the applications (several months) and on the foliar dissipation half life of 5.3 days, it is expected that the 2 applications would be representative of single applications. Therefore, only one application is modeled for this use.

To calculate EECs for terrestrial insects exposed to diazinon, T-REX is also used. Dietary-based EECs calculated by T-REX for small and large insects (units of a.i./g) are used to bound an estimate of exposure to bees. Available acute contact toxicity data for bees exposed to diazinon (in units of µg a.i./bee), are converted to µg a.i./g (of bee) by multiplying by 1 bee/0.128 g.
The EECs are later compared to the adjusted acute contact toxicity data for bees in order to derive RQs.

3.2.2.2. Terrestrial Animal Exposure Modeling Results

For modeling purposes, exposures of the CRLF to diazinon through contaminated food are estimated using the EECs for the small bird (20 g) which consumes small insects. Dietary-based and dose-based exposures of potential prey are assessed using the small mammal (15 g) which consumes short grass. Upper-bound Kenega nomogram values reported by T-REX for these two organism types are used for derivation of EECs for the CRLF and its potential prey (**Table 19**). Dietary-based EECs for small and large insects reported by T-REX as well as the resulting adjusted EECs are available in **Table 20**. An example output from T-REX v. 1.3.1 is available in **Appendix D**.

Table 19. Upper-bound Kenega nomogram EECs for dietary- and dose-based exposures of the CRLF and its prey to diazinon.

Use	EECs for CRLF		EECs for Prey (small mammals)	
	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)	Dietary-based EEC (ppm)	Dose-based EEC (mg/kg-bw)
Almonds	405	461.25	720	686.46
Blueberries	135	153.75	240	228.82
Caneberries	270	307.5	480	457.64
Fig	67.5	76.88	120	114.41
lettuce	270	307.5	480	457.64
Melons	540	615.01	960	915.29
outdoor ornamentals (26 aps)	160.76	183.09	285.8	272.49
outdoor ornamentals (1 ap)	135	153.75	240	228.82
strawberries	135	153.75	240	228.82
Tree fruit	270	307.5	480	457.64

Table 20. EEC (ppm*) for indirect effects to the terrestrial-phase CRLF through effects to potential prey items (terrestrial invertebrates).

Use	Small Insect	Large Insect
Almonds	405	45
Blueberries	135	15
Caneberries	270	30
Fig	68	7.5
Lettuce	270	30
Melons	540	60
outdoor ornamentals (26 aps)	161	18
outdoor ornamentals (1 ap)	135	15
Strawberries	135	15
Tree fruit	270	30

*Upper bound "Dietary-based EEC" estimated by T-REX. In this case, ppm = µg a.i./g of bee.

3.2.3. Spray Drift Modeling

In order to determine terrestrial habitats of concern due to diazinon exposures through spray drift, it necessary to estimate the distance spray applications can drift from the treated field and still be greater than the level of concern. For this assessment, the level of concern for the most sensitive endpoint and exposure duration is used. When this is expressed as an equivalent rate per unit area, it is 5×10^{-4} lb a.i./A. This assessment requires the use of two different spray drift models: AGDisp and AgDRIFT. AGDisp (version 8.13; dated 12/14/2004) (Teske and Curbishley, 2003) is used to simulate aerial and ground applications using the Gaussian farfield extension while AgDrift (version 2.01; dated 5/24/2001) is used to simulate spray blast applications to orchard crops.

Scenario and management practice input parameters for AgDisp fall into three categories. First, parameters for which there is current guidance. In all cases, there was no information from diazinon labels relevant to these parameters so they have been set to the default values recommended by the current draft EFED Guidance for AgDisp (EFED 2005). Second, default input values for AgDisp that do not affect the results of these calculations, or are reference variables whose value would only changed under special circumstances. “Wind speed” is an example of the former and “Height for wind speed measurement” is an example of the latter. These parameters have ‘ NA’ for not applicable in the quality column. Third, parameters for which no current guidance is available and the default value for AgDisp was used for the input parameter for this set of simulations. The justification for these parameters is “program default” in **Table 21**.

The quality column in **Table 21** provides some qualitative characterization regarding the confidence in the accuracy of that input parameter. When little or no information is available to support the value of a particular input parameter, the characterization in the quality column is poor. In many cases, when this occurs, the variable is set to a value that will produce drift values greater than those than that which would actually occur, so the results will likely be conservative and protective. When the amount of information supporting a parameter value is typical, the characterization is 'good' and the characterization is 'very good' or 'excellent' when a several measurements of high quality support the value for the parameter.

Table 21. Scenario and standard management input parameters for simulation of diazinon in spray drift using AgDisp with Gaussian farfield extension.

Parameter	Value	Justification	Quality
Nozzle type[1]	Flat fan	Program default	Poor
Boom Pressure[1]	60 lb	Program default	Poor
Spray lines	20	Program default	Poor
Nozzles	42	None available	Poor
Droplet Size Distribution (DSD)	Fine to very fine	Default; draft guidance	NA
Swath Width	60 ft	Program default	good
Wind Speed	15 mph	Default; draft guidance	good
Wind direction	- 90°	Default	NA
Air temperature	65° F	Program default	poor
Relative Humidity	50%	Program default	poor
Spray Material	Water	Program default	good
Fraction of active solution that is non-volatile	0.1	Program default	poor
Fraction of additive solution that is non-volatile	0.1	Program default	poor
Upslope angle	0°	Assume flat surface	good
Side slope angle	0°	Assume flat surface	god
Canopy type	none	Default from guidance	por
Surface roughness	0.0246 ft	Program default, none provided	poor
Transport	0 ft	Program default	poor
Height for wind peed measurement	6.56 ft	Program default	Good
Maximum comp. Time	600 sec	Program default	NA
Maximum downwind distance	2608.24 ft	Program default	NA
Vortex decay rate OGE	0.03355	Program default	NA
Vortex decay rate IGE	1.25	Program default	NA
Aircraft drag coefficient	0.1	Program default	NA
Propeller efficiency	0.8	Program default	NA
Ambient pressure	29.91	Program default	NA
Ground reference	0 ft	Program default	NA
Evaporation rate	84.76 $\mu g \cdot (K \cdot s)^{-1}$	Program default	NA
Specific Gravity (non-volatile)	1.0	Program default	poor
1 – parameter for ground spray only			

AgDrift input parameters that vary with the crop and application type are in **Table 22**. The ground spray for diazinon is a pre-plant spray made directly on to the ground. For this application, an height of 6 inches is the most appropriate as the spray is usually made close to the ground surface; however, AgDisp does not produce values for reliable values for these simulations when the spray height was set at less than 3 ft. The default release height of 15 ft is used for aerial applications in the absence of other label directions. Spray volumes are the minimum spray volumes from diazinon labels for each crop. The non-volatile fraction, active fraction and specific gravity were calculated from label information according to current guidance (EFED 2005). The default ½ swath displacement was used with the aerial spray for lettuce as it is standard practice for aerial sprays, but was not used with the ground sprays.

Table 22. AgDrift Input parameters that vary with crop and formulation.

Crop	Lettuce	Melons	Vegetables	Strawberries
App. Method	Aerial (Air Tractor AT 401)	ground	ground	ground
Release height	15 ft	3 ft	3 ft	3 ft
Swath Displacement	½ swath	none	none	none
Spray Volume	10 gal·acre^{-1}	5 gal·acre^{-1}	5 gal·acre^{-1}	100 gal·acre^{-1}
Non-volatile fraction	0.1	0.2	0.1	0.0025
Active Fraction	0.048	0.096	0.048	1.2 x 10^{-4}
Specific Gravity (carrier)	0.998	0.998	0.998	0.998

Table 23 presents the results of the AgDisp modeling and shows the minimum distance, for lettuce, melons, vegetables and strawberries, where the area-based concentration of diazinon is below the LOC of 5x10^{-4} lb·acre^{-1}. As would be expected, the distance from the aerial application to lettuce is considerably larger than for the ground spray uses. Most drift events would be expected to have shorter distances due to lower wind speed. The 3-ft application height for the ground spray likely causes a substantial increase in these distances. In addition, a fine to very-fine spray has been assumed for the ground sprays and ground equipment generally produces a coarser spray. However, there is no language restricting the spray quality on the diazinon labels so the fine to very spray was used as it is the default in the absence of other label instructions. It should be noted that the Gaussian extension model used for estimating distances assumes that the terrain is completely flat and devoid of any vegetation or obstruction that could limit the movement of the plume and that wind is unidirectional and constant. As such, estimates derived from this model are likely to be highly conservative.

Table 23. Distance from the edge of the treated field to get below LOC for all taxa in the terrestrial habitat exposed to diazinon from applications with aerial or ground sprays. Most sensitive endpoint is represented by direct effects to CRLF due to acute, dose-based exposures to diazinon.

Use Pattern	App Rate	Distance, 15 mph wind speed
Lettuce (air)	2 lb·acre^{-1}	11617 ft
Melons (ground)	4 lb·acre^{-1}	3226 ft
Other vegetables (ground)	4 lb·acre^{-1}	4139 ft
Strawberries (ground)	1 lb·acre^{-1}	2791 ft

There is additional uncertainty concerning the drift distance for applications to strawberries. The label specifies a 100 gal/acre application volume. This seems an excessive amount for use with the ground equipment that would typically be used for application to strawberries and more appropriate for orchard spray blast equipment. Furthermore, this spray volume would be unlikely to be a 'fine to very fine spray'.

Airblast application simulations for orchard crops are performed with the AgDrift model. The airblast component is a regression model that relates the drift to various orchard types. The dormant orchard was used for these assessments as indeed most orchard applications of diazinon are made during the winter dormant season. This orchard type produces the greatest drift as there are no leaves on the trees in the winter to intercept the sprayed pesticide.

Two runs were made for to estimate the distance from the edge-of-field for blueberries, caneberries, tree fruit and almonds to be below the acute listed species LOC for all terrestrial animals (**Table 24**). The first run is made with the application rate as stated on the label. The resulting drift distances represent a median or 'typical' event. A second run was made at three times the application rate to represent a 90^{th} percentile event. Current guidance for aquatic applications is to triple the median drift percent to approximate a 90^{th} percentile drift percent. Tripling the application rate would have the same effect for calculating the distance to get below the LOC. Distances for these orchard crops are much shorter than for the ground and aerial sprays (**Table 24**). This is due to the large volume (and consequent large droplet size) which causes the spray to settle out of the air much more rapidly than the other spray methods.

Table 24. Distance from the edge of the treated field to get below LOC for crops with air blast application of diazinon.

Use Pattern	App Rate	Median drift	90% drift
		Distance	
Blueberries	1 lb a.i./A	375 ft	595 ft
Caneberries, tree fruit	2 lb a.i./A	503 ft	790 ft
Almonds	3 lb a.i./A	595 ft	933 ft

3.3. Long Range Transport Exposure Assessment

3.3.1. Background

Besides exposures of diazinon resulting from runoff and drift, exposure of the CRLF to diazinon through atmospheric transport and deposition cannot be precluded (Stein and White 1993; Majewski and Baston 2002). As described in the Diazinon IRED (2002), diazinon and its degradate diazoxon can be present in air or precipitation (*e.g.* rain and fog) due to spray drift, volatilization from application sites and/or wind erosion of soil containing residues (Unsworth *et al*. 1999). Wet (precipitation) and dry (particulate matter) deposition can contribute significantly to diazinon and diazoxon loads in aquatic systems (LeNoir *et al*. 1999; USGS 2003a). Deposition of diazinon and diazoxon could potentially be transported to aquatic and terrestrial habitats of the CRLF.

Ranges of diazinon transport in are unknown. Muir *et al*. (2004) estimated a half-distance (representing the distance traveled to reach a 50% decline in air concentration) of 440 (±153) miles for diazinon, based on empirical data from Canada. This group also estimated characteristic travel distances for diazinon of 1 to163 miles, depending upon model assumptions (*e.g.* related to precipitation, and degradation). The extent to which this could reasonably result in potential exposure of the CRLF to diazinon has not been assessed and remains an uncertainty.

At this time, an approved model for estimating atmospheric transport of pesticides and resulting exposure to organisms in areas receiving pesticide deposition from atmospheric transport is not available. Potential mechanisms of transport of diazinon to the atmosphere, such as volatilization, wind erosion of soil, and spray drift, can only be discussed qualitatively. Given the presence of diazinon in air and precipitation reported in monitoring data specific to California, exposure of CRLF and its habitats to diazinon through atmospheric transport cannot be precluded. The extent to which diazinon will be deposited from the air to the habitat of the CRLF, however, is unknown. In an attempt to estimate the amount of diazinon deposited into aquatic and terrestrial habitats, diazinon concentrations measured in rain samples taken in California are considered below in combination with California specific precipitation data and runoff estimates from PRZM.

As discussed in the uncertainties section of this assessment, diazoxon is a degradate of diazinon which has been observed in air and precipitation samples. Given the greater toxicity of this degradate as compared to the parent, risk from diazoxon exposure via this route cannot be precluded.

3.3.2. Qualitative discussion of potential transport mechanisms for long-range transport of diazinon

There are several potential mechanisms that can result in transport of diazinon from an application area to the atmosphere with subsequent wet or dry deposition of the compound to areas distant from the initial site of application. These mechanisms include 1) volatilization from soil and plant surfaces in treated areas, 2) wind erosion of soil containing sorbed diazinon and 3) drift of diazinon during spray treatments of fields.

There are several factors which can influence volatilization of diazinon from a treated area, including: vapor pressure, adsorption to soil, incorporation depth, Henry's law constant, diffusion coefficients (Woodrow *et al*. 1997). Diazinon has a vapor pressure of 1.40×10^{-4} mm Hg at 20^{o}C. The vapor pressure (1.4×10^{-4} torr) and reported Henry's law constant of 1.40×10^{-6} atm-m^3/mol indicate that diazinon would volatilize from soil and water.

In a study involving diazinon, evaporation rates were estimated for 6 days after applying the pesticide to a fallow field at a rate of 1.5 kg a.i./ha (Majewski *et al*. 1990). Observations indicated that evaporation occurred at different rates throughout the first 4 days after application, with no evaporation observed on the 5^{th} and 6^{th} days after application. Reported evaporation rates at different time steps over the 4 days following the application ranged from <0.1 to 38 µg/m^2• h. These rates represent an hourly loss of <0.000067 to 0.025% of the total diazinon applied to the field. Average evaporation rates over the 4-day period after the application (which were calculated with no consideration of time weight) were 1.69-6.84 µg/m^2• h, which translate to an evaporation of 2.8-11.3% of the total mass of diazinon which was applied to the field.

As discussed in the environmental fate and transport assessment section, batch equilibrium studies indicated that diazinon is relatively mobile and not expected to adsorb to soils of low organic carbon content to a significant degree. Therefore, wind erosion of soils containing bound diazinon is expected to contribute little to the overall mass of diazinon that is transported atmospherically.

As discussed above, diazinon contained in spray drift could potentially move miles from the application site at levels that are of concern to organisms in terrestrial habitats. Estimates of spray drift resulting from aerial applications of diazinon to lettuce indicate that diazinon could travel up to 3.54 km (11,617 feet) and be at levels of concern to terrestrial animals. As mentioned previously though, the Gaussian extension model relies on very conservative assumptions and thus its resulting estimates may have very limited utility since empirical data are not available to substantiate these estimates.

3.3.3. Air and precipitation monitoring data

Diazinon is one of the most frequently detected of the organophosphate pesticides in air and in precipitation (USGS 1997). The majority of monitoring studies involving diazinon have been in California; however, diazinon has been detected throughout the U.S. Available air and precipitation California monitoring data for diazinon are reported here in **Table 25**.

Table 25. Diazinon detections in air and precipitation samples taken in California.

Location	Year	Sample type	Maximum Conc.*	Detection frequency	Source
CA, MD	1970s-1990s	Air	0.306	NA	Reported in Majewski and Capel, 1995
Sequoia National Park, CA	1996	Air	0.00024	41.7%	LeNoir *et al.* 1999
Sacramento, CA (Franklin Field Airport)	1996-1997	Air	0.0191	37.1 %	Majewski and Baston 2002
Sacramento, CA (Sacramento Metropolitan Area)	1996-1997	Air	0.0122	46.5 %	Majewski and Baston 2002
Sacramento, CA (Sacramento International Airport)	1996-1997	Air	0.112	38.5 %	Majewski and Baston 2002
Fresno County, CA	1997	Air	0.290	NA	State of California, 1998 a
Fresno County, CA	1998	Air	0.160	NA	State of California, 1998 b
Sequoia national Park, CA	1995-1996	Rain	0.019	57 %	McConnell *et al.* 1998
San Joaquin River Basin, CA	2001	Rain	0.908	100%	Zamora et al. 2003
San Joaquin Valley, CA	2002-2004	Rain	2.22	93%	Majewski et al. 2005
CA, MD	1970s-1990s	Fog	76.3	NA	Reported in Majewski and Capel, 1995
Parlier, CA	1986	Fog	18.0	NA	Glotfelty *et al.* 1990
Monterey, CA	1987	Fog	4.80	NA	Schomburg *et al.* 1991
Sequoia national Park, CA	1995-1996	Snow	0.014	62.5 %	McConnell *et al.* 1998

*For Air, $\mu g/m^3$; for rain, snow and fog, $\mu g/L$

The magnitude of detected concentrations of diazinon in air and in precipitation can vary based on several factors, including proximity to use areas and timing of applications. In air, diazinon and has been detected at concentrations up to 0.306 $\mu g/m^3$. Measured concentrations of diazinon in rain in California have ranged up to 2.22 µg/L. In fog, diazinon has been detected up to 76.3 µg/L (Majewski and Capel, 1995).

3.3.4. Deposition Data

In a study of diazinon loads in winter precipitation and runoff to the San Joaquin River Basin, precipitation samples were collected from a January 2001 storm event. In order to observe the influences of dormant season applications of diazinon, four sampling sites were placed near areas dominated by orchards. Concentrations of diazinon measured in rainfall ranged 0.175-0.870 µg/L. The authors concluded that diazinon contained in precipitation could contribute significantly to the overall diazinon load contained in runoff (Zamora et al. 2003).

In a 3.5 year study (from 2001-2004) in the central San Joaquin Valley, wet and dry deposition of pesticides, including diazinon, were monitored at 6 sites, including some with agricultural and urban landcovers. When comparing wet and dry deposition, wet deposition represented a more significant source of diazinon. Diazinon was detected in 93% of rain samples (n=137), with mean and maximum concentrations of 0.149 and 2.220 µg/L, respectively. (Majewski *et al*. 2006).

3.3.5. Monitoring data from lakes assumed to only receive atmospheric deposition of diazinon

Studies are available involving monitoring of diazinon concentrations in California lakes which are removed from agricultural areas and are presumed to receive inputs of diazinon from atmospheric deposition only. Two 1997 studies (Fellers *et al.* 2004; LeNoir *et al.* 1999) measured diazinon concentrations in lake water in Kings Canyon and Sequoia National Parks (located in the Sierra Nevada Mountains in California). Fellers *et al*. (2004) reported a maximum concentration of 0.0034 µg/L, and LeNoir *et al.* (1999) reported a maximum concentration of 0.0741 µg/L in lake water. The authors attributed these detections to atmospheric deposition from dry deposition and/or gas exchange from air samples of diazinon originating from agricultural sites located in California's Central Valley, which is up wind of the lakes.

3.3.6. Modeling of contributions of wet deposition to aquatic and terrestrial habitats

In an attempt to estimate the amount of diazinon deposited into aquatic and terrestrial habitats, diazinon concentrations measured in rain samples taken in California were considered in combination with California specific precipitation data and runoff estimates from PRZM. Precipitation and runoff data associated with the PRZM scenarios used to model aquatic EECs were used to determine relevant 1-in-10 year peak runoff and rain events. The scenarios included were: CA almond, CA lettuce, CA wine grape, CA row crop, CA fruit, CA nursery, and CA onion. The corresponding meteorological data were from the following locations: Sacramento, Santa Maria, San Francisco, Monterey County, Fresno, San Diego, and Bakersfield, respectively.

To estimate concentrations of diazinon in the aquatic habitat resulting from wet deposition, the daily PRZM-simulated volume of runoff from a 10 ha field is combined with an estimate of daily precipitation volumes over the 1 ha farm pond relevant to the EXAMS environment. This volume is multiplied by the maximum concentration of diazinon in precipitation reported in monitoring data, which is 2.22 µg/L. The result is a daily mass load of diazinon into the farm pond. This mass is then divided by the volume of water in the farm pond (2.0×10^7 L) to achieve a daily estimate of diazinon concentration in the farm pond, which represents the aquatic habitat. From the daily values, the 1-in-10 year peak estimate of the concentration of diazinon in the aquatic habitat is determined for each PRZM scenario (**Table 26**). Concentrations estimated using this approach are 1-2 orders of magnitude greater than those reported by Fellers et al. (2004) and LeNoir et al. (1999) in mountain lakes assumed to be receiving diazinon loading only from atmospheric deposition. This difference in concentrations is reasonable since the mountain lakes where diazinon was detected were spatially removed from diazinon use areas; while the location where the maximum detected concentration of diazinon was observed in precipitation was in close proximity to agricultural uses of diazinon. There are several assumptions associated with this approach, including: 1) the concentration of diazinon in the rain event is spatially and temporally homogeneous (e.g. constant over the 10 ha field and 1 ha pond for the entire rain event); 2) the entire mass of diazinon contained in the precipitation runs off of the pond or is deposited directly into the pond; 3) there is no degradation of diazinon between the time it leaves the air and the time it reaches the pond.

Table 26. 1-in-10 year peak estimates of diazinon concentrations in aquatic and terrestrial habitats resulting from deposition of diazinon at 2.22 µg/L diazinon in rain.

Met Station	Scenario	Concentration in aquatic habitat (µg/L)	Deposition on terrestrial habitat (lbs a.i./A)
Sacramento	CA almond	0.414	0.0014
Santa Maria	CA lettuce	0.445	0.0011
San Francisco	CA wine grape	0.390	0.0013
Monterey Co.	CA row crop	0.358	0.0014
Fresno	CA fruit	0.162	0.0008
San Diego	CA nursery	0.300	0.0010
Bakersfield	CA onion	0.119	0.0005

To estimate deposition of diazinon on the terrestrial habitat resulting from wet deposition, the daily volume of water deposited in precipitation on 1 acre of land is estimated. This volume is multiplied by the maximum concentration of diazinon in precipitation reported in monitoring data, which is 2.22 µg/L. The result is a mass load of diazinon per acre (converted to units of lbs a.i./A). From the daily values, the 1-in-10 year peak estimate of the deposition of diazinon on the terrestrial habitat is estimated for each PRZM scenario (**Table 26**). In this approach, it is assumed that the concentration of diazinon in the rain event is spatially and temporally homogeneous (e.g. constant over the 1 A of terrestrial habitat for the entire rain event).

4. Effects Assessment

This assessment evaluates the potential for diazinon to adversely affect the CRLF. As previously discussed in Section 2.7, assessment endpoints for the CRLF include direct toxic effects on the survival, reproduction, and growth of the CRLF itself, as well as indirect effects, such as reduction of the prey base and/or modification of its habitat. Direct effects to the CRLF in aquatic habitats are based on toxicity information for freshwater vertebrates, including fish, which are generally used as a surrogate for amphibians, as well as available amphibian toxicity data from the open literature. Direct effects to the CRLF in terrestrial habitats are based on toxicity information for birds, which are generally used as a surrogate for terrestrial-phase amphibians. Given that the CRLF's prey items and habitat requirements are dependent on the availability of freshwater aquatic invertebrates and aquatic plants, fish, frogs, terrestrial invertebrates and terrestrial mammals, toxicity information for these organisms is also discussed. Acute (short-term) and chronic (long-term) toxicity information is characterized based on registrant-submitted studies and a comprehensive review of the open literature on diazinon. A summary of the available freshwater ecotoxicity information, use of the probit dose response relationship, and the incident information for diazinon are provided in Sections 4.1 through 4.4, respectively. A detailed summary of the available ecotoxicity information for diazinon formulated products is presented in **Appendix A.**

The available information indicates that aquatic organisms are more sensitive to the technical grade (TGAI) than the formulated products of diazinon; therefore, the focus of this assessment is on the TGAI of diazinon.

Toxicity endpoints are established based on data generated from guideline studies submitted by the registrant, and from open literature studies that meet the criteria for inclusion into the ECOTOX database maintained by EPA/Office of Research and Development (ORD) (U.S. EPA, 2004). Open literature data presented in this assessment were obtained from the 2000 diazinon IRED (U.S. EPA, 2000a) as well as information obtained from ECOTOX on December 14, 2006. The December 2006 ECOTOX search included all open literature data for diazinon and diazoxon (*i.e.*, pre- and post-IRED). In order to be included in the ECOTOX database, papers must meet the following minimum criteria:

- the toxic effects are related to single chemical exposure;
- the toxic effects are on an aquatic or terrestrial plant or animal species;
- there is a biological effect on live, whole organisms;
- a concurrent environmental chemical concentration/dose or application rate is reported; and
- there is an explicit duration of exposure.

Data that pass the ECOTOX screen are evaluated along with the registrant-submitted data, and may be incorporated qualitatively or quantitatively into this endangered species assessment. In general, effects data in the open literature that are more conservative than the registrant-submitted data are considered.

4.1. Evaluation of Aquatic Ecotoxicity Studies for Diazinon

As described in the Agency's Overview Document (U.S. EPA, 2004), the most sensitive endpoint for each taxa is evaluated. For this assessment, evaluated taxa relevant to the aquatic habitat of the CRLF include freshwater fish, freshwater aquatic invertebrates, and freshwater aquatic plants. Currently, no guideline tests exist for frogs. Therefore, surrogate species are used as described in the Overview Document (U.S. EPA, 2004). In addition, aquatic-phase amphibian ecotoxicity data from the open literature are qualitatively discussed. **Table 27** summarizes the most sensitive ecological toxicity endpoints for the CRLF, its prey and its habitat, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this ecological risk assessment for the CRLF is presented below. Additional information is provided in **Appendix A**

Table 27. Aquatic Toxicity Profile for Diazinon (used for RQ derivation).

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Probit Slope	Citation MRID # (Author & Date)	Comment
Acute Direct Toxicity to CRLF (also indirect effects to CRLF via acute toxicity to fish and frogs (prey))	Rainbow trout[1]	96-hour LC_{50} = 90 µg/L	4.5	400946-02 (Johnson and Finley 1980)	Acceptable
Chronic Direct Toxicity to CRLF (also indirect effects to CRLF via acute toxicity to fish and frogs (prey))	Brook trout[1]	NOAEC <0.55 µg/L LOAEC = 0.55 µg/L (reduced growth)	N/A	ROODI007 (Allison and Hermanutz 1977)	Acceptable
Indirect Effects to CRLF via Acute Toxicity to Freshwater Invertebrates (*i.e.* prey items)	Water flea (*Ceriodaphnia dubia*)	48-hour EC_{50} = 0.21 µg/L	6.34[2]	Banks *et al.* 2005	Supplemental
Indirect Effects to CRLF via Chronic Toxicity to Freshwater Invertebrates (*i.e.* prey items)	Water flea (*D. magna*)	NOAEC = 0.17 µg/L LOAEC = <0.32 µg/L	N/A	407823-02 (Supernant 1988)	Supplemental
Indirect Effects to CRLF via Acute Toxicity to Non-vascular aquatic plants	Green algae	EC_{50} = 3,700 µg/L EC_{05}= 66 µg/L (decreased growth)	0.90	405098-06	Acceptable

[1] Used as a surrogate for the CRLF. [2] Estimated slope from aquatic invertebrate studies (see **Appendix I**)

Acute toxicity to aquatic fish and invertebrates is categorized using the system shown in **Table 28** (U.S. EPA, 2004). Toxicity categories for aquatic plants have not been defined. Based on these categories, at most, diazinon is classified very highly toxic to freshwater fish and invertebrates on an acute exposure basis.

Table 28. Categories of Acute Toxicity for Aquatic Organisms.

LC_{50} (µg/L)	Toxicity Category
< 100	Very highly toxic
> 100 – 1,000	Highly toxic
> 1,000 – 10,000	Moderately toxic
> 10,000 – 100,000	Slightly toxic
> 100,000	Practically nontoxic

4.1.1. Toxicity to Freshwater Fish

As previously discussed, no guideline toxicity tests currently exist for frogs; therefore, freshwater fish are used as surrogate species for amphibians including frogs (U.S. EPA, 2004). The available open literature information on diazinon toxicity to aquatic-phase amphibians, which is provided in **Section 4.1.2**, shows that acute and chronic ecotoxicity endpoints for amphibians are generally less sensitive than fish. Therefore, endpoints based on freshwater fish ecotoxicity data are assumed to be protective of potential direct effects to aquatic-phase amphibians, including the CRLF. A summary of acute and chronic freshwater fish data, including sublethal effects, is provided below.

4.1.1.1. Freshwater Fish: Acute Exposure (Mortality) Studies

Freshwater fish acute toxicity studies are used to assess potential direct effects to the CRLF because direct acute toxicity guideline data on frogs are unavailable. Diazinon toxicity has been evaluated in numerous freshwater fish species, including rainbow trout, brook trout, bluegill sunfish, fathead minnow, tilapia, zebrafish, goldfish, and carp. The results of these studies demonstrate a wide range of sensitivity to diazinon. The range of acute freshwater fish LC_{50} values for diazinon spans one order of magnitude, from 90 to 7,800 µg/L; therefore, diazinon is categorized as very highly (LC_{50} < 100 µg/L) to moderately (LC_{50} >1,000 to 10,000 µg/L) toxic to freshwater fish on an acute exposure basis. The freshwater fish acute LC_{50} value of 90 µg/L is based on a static 96-hour toxicity test using rainbow trout (*Oncorhynchus mykiss*) (MRID # 400946-02). No sublethal effects were reported as part of this study. A complete list of all the acute freshwater fish toxicity data for diazinon is provided in **Table A-8** of **Appendix A**.

4.1.1.2. Freshwater Fish: Chronic Exposure (Growth/Reproduction) Studies

Similar to the acute data, chronic freshwater fish toxicity studies are used to assess potential direct effects to the CRLF because direct chronic toxicity guideline data for frogs do not exist. The chronic effects of diazinon on fathead minnows (*Pimephales promelas*) and brook trout (*Salvelinus fontinalis)* were determined in flow-through systems with constant toxicant concentrations (Allison and Hermanutz 1977). Fathead minnows exposed to the lowest concentration tested (3.2 μg/L) from 5 days after hatch through spawning had a significantly higher incidence of scoliosis than the control (p=0.05). Hatch of their progeny was reduced by 30% at this concentration. Yearling brook trout exposed to 4.8 μg/L and above began developing scoliosis and lordosis within a few weeks. Growth of brook trout was substantially inhibited during the first 3 months at 4.8 μg/L and above. Neurological symptoms were evident in brook trout at 2.4 μg/L and above early in the tests, but were rarely observed after 4 or 5 months of exposure. Exposure of mature brook trout for 6 to 8 months to concentrations ranging from 9.6 μg/L to the lowest tested (0.55 μg/L) resulted in equally reduced growth rates for their progeny. Transfer of progeny between concentrations indicated that effects noted for progeny of both species at lower concentrations were the result of parental exposure alone and not the exposure of progeny following fertilization. At this time, there are no data for diazinon that meet guidelines testing requirements for establishing a chronic NOAEC in freshwater fish. However, the registrant is in the process of completing these studies in response to a data call-in. Based on the information discussed above, the NOAEC is less than the lowest concentration tested using brook trout (NOAEC <0.55 μg/L).

4.1.1.3. Freshwater Fish: Sublethal Effects and Additional Open Literature Information

In Atlantic salmon (*Salmo salar*), neuroendocrine-mediated olfactory functions were affected at 1.0 μg/L diazinon (Moore and Waring 1996). The reproductive priming effect of the female pheromone prostaglandin $F_{2\alpha}$ on the levels of expressible milt in males was reduced after exposure to diazinon at 0.5 μg/L. Overall, the relationship between reduced olfactory response of males to the female priming hormone in the laboratory and reduction in salmon reproduction (*i.e.*, the ability of male salmon to detect, respond to, and mate with ovulating females) in the wild is not established.

In a study of chinook salmon (*Oncorhynchus tshawytscha*) antipredator behavior by Scholz *et al* (2000), diazinon exposure resulted in significant effects of swimming and feeding behavior at concentrations of 1 μg/L; fish remained more active and fed more frequently in the presence of an alarm stimulus (skin extract) relative to controls. The effect of diazinon on chinook salmon homing success was also examined in the Scholz *et al* (2000) study. Significantly fewer salmon returned after exposure to 10 μg/L diazinon. This study has been more thoroughly reviewed (**Appendix A**) and there is considerable uncertainty regarding the extent to which diminished olfactory response as it related to predator avoidance and homing behavior will affect the survival and reproduction of fish. In this study, chinook salmon survival was not impaired.

In addition, EPA did not use these data in development of the aquatic life water quality criteria for diazinon because population level effects of specific chemicals on the olfactory system of aquatic organisms can only be hypothesized at this time and not substantiated (no articles were obtained that evaluated this issue satisfactorily). The primary unanswered question is how serious of an impact does the temporary loss of olfactory function and associated altered behavior have on the homing, migratory patterns, feeding activity and avoidance of predators for the exposed organisms, and more importantly, on the ability of the exposed population to reproduce, grow and ultimately survive in the wild. Thus, the impact of sublethal effects on the long-term survival of an exposed aquatic population is very difficult to determine from laboratory studies, and therefore complex long-term field studies are needed to address this issue.

Although these studies raise concern about the effects of diazinon on endocrine-mediated functions in freshwater and anadromous fish, these effects are difficult to quantify because they are not clearly tied to the assessment endpoints for the CRLF (*i.e.*, survival, growth, and reproduction of individuals). In addition, differences in habitat and behavior of the tested fish species compared with the CRLF suggest that the results are not readily extrapolated to frogs. Furthermore, there is uncertainty associated with extrapolating effects observed in the laboratory to more variable exposures and conditions in the field. Therefore, potential sublethal effects on fish are evaluated qualitatively and not used as part of the quantitative risk characterization. Further detail on sublethal effects to fish is provided in **Appendix A**.

4.1.2. Toxicity to Aquatic-phase Amphibians

Available acute toxicity data for amphibians indicate that they may be relatively insensitive to diazinon when compared to fish. A 96-h LC_{50} of 7,488 μg/L, based on nominal concentrations, was identified in the literature for the mountain yellow-legged frog (*Rana boylii*), which is in the same genus as the CRLF (Sparling and Fellars 2006). Guideline ecotoxicity studies for amphibians are not available.

No chronic toxicity data are available for aquatic-phase amphibians.

4.1.3. Toxicity to Freshwater Invertebrates

Freshwater aquatic invertebrate toxicity data are used to assess potential indirect effects of diazinon to the CRLF. Direct effects to freshwater invertebrates resulting from exposure to diazinon may indirectly affect the CRLF via reduction in available food. As discussed in **Attachment 1**, the diet of CRLF aquatic-phase larvae (tadpoles) has not been studied specifically; it is assumed that their diet is similar to that of other frog species, with the tadpoles feeding exclusively in water and consuming diatoms, algae, and detritus (USFWS 2002). Post-metamorphic terrestrial-phase CRLFs feed on aquatic and terrestrial invertebrates found along the shoreline and on the water surface. Based on stomach content analysis, adults feed on a variety of invertebrates with larger-sized frogs feeding on small fish, frogs, and small mammals (Hayes and Tennant 1985).

A summary of acute and chronic freshwater invertebrate data, including published data in the open literature since completion of the IRED (U.S. EPA, 2006), is provided below in **Sections 4.1.3.1 through 4.1.3.3**.

4.1.3.1. Freshwater Invertebrates: Acute Exposure Studies

Diazinon is classified as very highly toxic to aquatic invertebrates. Toxicity estimates, EC_{50} and LC_{50} values, for freshwater invertebrates ranged from 0.8 to 35 µg/L. Although the original ecological risk assessment of diazinon reported a 96-hr LC_{50} as low as 0.2 µg/L for scuds (*Gammarus fasciatus*), a reanalysis of the raw data indicated that the 96-hr LC_{50} value was off by an order of magnitude and that the correct value is 2 µg/L (U.S. EPA Memo to SRRD dated 10/05/2005). Data were located through ECOTOX indicating that diazinon is very highly toxic to *Ceriodaphnia dubia* (48-hr EC_{50}= 0.21 µg/L) (Banks *et al*. 2005). All of the available acute toxicity data for freshwater invertebrates are provided in **Appendix A**.

4.1.3.2. Freshwater Invertebrates: Chronic Exposure Studies

The most sensitive chronic endpoint for freshwater invertebrates is based on a 21-day flow-through study on waterfleas (*Daphnia magna*), which showed significant effects on survival (100% mortality) at diazinon concentrations greater than 0.17 µg/L; the NOAEC and LOAEC for this study are 0.17 and 0.32 µg/L, respectively (MRID # 407823-02).

4.1.4. Toxicity to Aquatic Plants

Aquatic plant toxicity studies are used as one of the measures of effect to evaluate whether diazinon may affect primary production. Primary productivity is essential for indirectly supporting the growth and abundance of the CRLF. In addition to providing cover, aquatic plants harbor a variety of aquatic invertebrates that aquatic-phase CRLF eat.

Two types of studies are used to evaluate the potential of diazinon to affect primary productivity. Laboratory studies are used to determine whether diazinon may cause direct effects to aquatic plants. In addition, the threshold concentrations, described in **Section 4.2**, are used to further characterize potential community level effects to CRLF resulting from potential effects to aquatic plants. A summary of the laboratory data for aquatic plants is provided in **Section 4.1.4.1**.

4.1.4.1. Toxicity to Freshwater Plants

A single aquatic plant study is available for determining the toxicity of diazinon to aquatic plants. Toxicity testing with green algae (*Pseudokirchneriella subcapitata*) resulted in a 7-day EC_{50} of 3,700 µg/L (MRID 405098-06). A reanalysis of the data to estimate an EC_{05} was conducted using the Probit procedure of the Statistical Analysis System (Release 9.1; SAS Institute, Inc., Cary, NC); the probit-estimated EC_{05} is 66 µg/L; the probit dose-response slope is relatively shallow at 0.90.

No data are available to assess the toxicity of diazinon to aquatic vascular plants; however, the toxicity data for nonvascular plants suggests that plants are not particularly sensitive to diazinon mode of action as an inhibitor of the enzyme acetyl choline esterase. Additionally, as discussed below, mesocosm studies further substantiate that aquatic plants are not sensitive to diazinon.

4.1.5. Freshwater Field Studies

Mesocosm studies with diazinon provide measurements of primary productivity that incorporate the aggregate responses of multiple species in aquatic communities. Because various aquatic species vary widely in their sensitivity to diazinon, the overall response of the aquatic community may be different from the responses of the individual species measured in laboratory toxicity tests. Mesocosm studies allow observation of population and community recovery from diazinon effects and of indirect effects on higher trophic levels. In addition, mesocosm studies, especially those conducted in outdoor systems, incorporate partitioning, degradation, and dissipation, factors that are not usually accounted for in laboratory toxicity studies, but that may influence the magnitude of ecological effects.

Diazinon has been the subject of a mesocosm study where 450-m^2 ponds were monitored following 6 applications of diazinon, alternating between spray drift events and simulated runoff events separated by 1-wk intervals (MRID 425639-01). Nominal treatment concentrations were equivalent to 5.7, 11.4, 22.9, 45.8 and 91.5 µg a.i./L of pond water. Diazinon was shown to have strongly affected the zooplankton taxon Cladocera, where abundance was significantly reduced in all treatments in 5 (36%) of 14 sample periods. Tricoptera abundance was also significantly reduced in all treatments for 29% of the sample periods. Dipterans were also significantly affected. The overall impact of diazinon on the aquatic community was that many aquatic invertebrates were affected at treatment concentrations greater than 11 µg a.i./L; however, most taxa recovered after treatment. Although significant reductions were observed in macroinvertebrate abundance throughout the study period, fish and plants were generally unaffected by the diazinon treatments. Under the study conditions tested, mesocosms treated with multiple applications of diazinon did not reveal any statistically significant direct or indirect effects on fish even though there were significant fluctuations in aquatic macroinvertebrates due to diazinon. A more complete description of this study is located in **Appendix A**.

4.2. Evaluation of Terrestrial Ecotoxicity Studies for Diazinon

As described in the Agency's Overview Document (U.S. EPA, 2004), the most sensitive endpoint for each taxa is evaluated. For this assessment, evaluated taxa include birds, mammals, terrestrial invertebrates and terrestrial plants. Currently, no guideline tests exist for frogs and thus, no toxicity data are currently required on amphibians. Therefore, surrogate taxa (birds) were used as described in the Overview Document (U.S. EPA, 2004).

Similar to toxicity categories for aquatic organisms, categories of acute toxicity ranging from "practically nontoxic" to "very highly toxic" have been established for terrestrial organisms based on LD_{50} values (**Table 29**), and avian species based on LD_{50} values (**Table 30**). Subacute dietary toxicity for avian species is based on the LC_{50} values (**Table 31**).

Table 29. Categories for mammalian acute toxicity based on median lethal dose in mg per kilogram body weight (parts per million).

LD_{50} (mg a.i./kg)	Toxicity Category
<10	Very highly toxic
10–50	Highly toxic
51–500	Moderately toxic
501–2000	Slightly toxic
>2000	Practically non-toxic

Table 30.Categories of avian acute oral toxicity based on median lethal dose in milligrams per kilogram body weight (parts per million).

LD_{50} (ppm)	Toxicity Category
<10	Very highly toxic
10-50	Highly toxic
51-500	Moderately toxic
501-2000	Slightly toxic
>2000	Practically non-toxic

Table 31. Categories of avian subacute dietary toxicity based on median lethal concentration in milligrams per kilogram diet per day (parts per million).

LC_{50} (ppm)	Toxicity Category
<50	Very highly toxic
50–500	Highly toxic
501–1000	Moderately toxic
1001–5000	Slightly toxic
>5000	Practically non-toxic

Table 32 summarizes the most sensitive ecological toxicity endpoints for terrestrial-phase CRLF, based on an evaluation of both the submitted studies and the open literature, as previously discussed. A brief summary of submitted and open literature data considered relevant to this

ecological risk assessment for the CRLF are presented below. Additional information is provided in **Appendix A.**

Table 32. Terrestrial Toxicity Profile for Diazinon. These data are used for deriving RQs for the relevant assessment endpoints.

Assessment Endpoint	Species	Toxicity Value Used in Risk Assessment	Probit Slope	Citation MRID # (Author & Date)	Comment
Acute Direct Toxicity to CRLF	Mallard Duck[1]	LD_{50} = 1.44 mg/kg	2.92	40895301 (Fletcher and Pedersen 1988)	Acceptable
Subacute Direct Toxicity to CRLF	Mallard Duck[1]	LC_{50} = 32 ppm	5.6[2]	40895302 (Fletcher and Pedersen 1988)	Acceptable
Chronic Direct Toxicity to CRLF	Mallard Duck[1]	NOAEC 8.3 ppm LOAEC = 16.33 ppm	NA	43122901 (Marselas 1989)	Significant reduction in # of 14-d hatchling survivors. Acceptable
Indirect Effects to CRLF via Acute Toxicity to Terrestrial Invertebrates (*i.e.* prey items)	Honey Bee	LD_{50} (contact) = 0.22 µg/bee (equivalent to 1.72 µg/g-bee)	9.4	05004151 (Stevenson 1968)	Acceptable
Indirect Effects to CRLF via Acute Toxicity to Terrestrial Mammals (*i.e.* prey items)	Laboratory Rat	LD_{50} =882 mg/kg (females) LD_{50} =968 mg/kg (males) LD_{50} =936 mg/kg	4.5[3]	41334607	Acceptable
Indirect Effects to CRLF via Chronic Toxicity to Terrestrial Mammals (*i.e.* prey items)	Laboratory Rat	NOAEC = 10 ppm LOAEC = 100 ppm	NA	41158101 (Novartis 1989)	Decreased parental and pup weight gain. Pup mortality. Acceptable
Indirect Effects to CRLF via Toxicity to Terrestrial plants (monocots) (*i.e.* habitat)	Oat	Seedling Emergence EC_{50} = 5.26 lbs a.i./A	1.28	40803001 (Pan-Agricultural Labs 1988) 40803002 (Pan-Agricultural Labs 1988)	Effects to shoot height. Acceptable
	Onion	Vegetative Vigor EC_{50} >7.0 lbs a.i./A			
Indirect Effects to CRLF via Toxicity to Terrestrial plants (dicots) (*i.e.* habitat)	Carrot	Seedling Emergence EC_{50} = 9.03 lbs a.i./A	0.17	40803001 (Pan-Agricultural Labs 1988) 40803002 (Pan-Agricultural Labs 1988)	Effects to shoot height. Acceptable
	Cucumber	Vegetative Vigor EC_{50} 3.23 lbs a.i./A			

[1] Used as a surrogate for the CRLF in terrestrial habitats.
[2] Slope taken from 8-day dietary toxicity test with mallard duck (MRID 408953-08) where LC_{50}=38 ppm.
[3] Default slope 4.5

4.2.1. Toxicity to Birds

Diazinon is categorized as very highly toxic (LD_{50}<10 mg a.i./kg; LC_{50}<50 ppm) to birds on an acute exposure basis. The chronic toxicity of diazinon was evaluated in laboratory-based avian reproduction studies using the Bobwhite quail and mallard duck; these studies are designed to estimate the quantity of toxicant required to adversely affect the reproductive capabilities of a test population of birds. The TGAI is administered by mixture to breeding birds' diets throughout their breeding cycle. Test birds are approaching their first breeding season and, generally, are 18-to-23 weeks old. The onset of the exposure period is at least 10 weeks prior to egg laying. Exposure period during egg laying is generally 10 weeks with a withdrawal period of three additional weeks if reduced egg laying is noted. Results are expressed as no observed adverse effect level (NOAEL) and various observable effect levels, such as the lowest observed adverse effect level (LOAEL), quantified in units of parts per million of active ingredient (ppm a.i.) in the diet. A statistically significant reduction in the number of 14-day old hatchlings occurred when mallard duck mated pairs were fed diets containing 16.3 ppm or greater of diazinon. The study involving ring-neck pheasant and treated seed indicated that when diazinon comprised 6-to-12 % of the test subjects' daily food intake they experienced weight loss and reduced egg production. Therefore, outdoor use resulting in exposure to birds as well as terrestrial-phase amphibians at concentrations at or greater than 8.3 ppm preceding or during the breeding season may cause reproductive effects.

4.12.2. Toxicity to Terrestrial-phase Amphibians

The EFED ecotoxicity database reports an LD_{50} of greater than 2000 mg/kg for terrestrial-phase bullfrogs (*R. catesbiana*).

4.2.3. Toxicity to Mammals

Diazinon is categorized as slightly toxic (defined as: LD_{50} = 501-2000 mg a.i./kg) to small mammals on an acute oral basis. Although the original risk assessment (U.S. EPA, 2002) identified a more sensitve acute oral toxicity (LD_{50}=505 mg/kg; MRID 414070-02), a review of this study indicated that the LD_{50} exceeded the highest concentration tested (LD_{50}>505 mg/kg). Based on information reviewed by the OPP Health Effects Division (HED), the most sensitive acute rat oral toxicity $LD_{50}$is 882 mg/kg based on female rats (MRID 413346-07). In the same study, the acute toxicity of diazinon for male rats was 968 mg/kg and the toxicity to combined males and females was 936 mg/kg.

In chronic exposures, treatment-related effects involved decreased food consumption and body weight gain and increased mortality in the offspring when the mother rat was exposed to daily doses of 20 milligrams per kilogram of her body weight (mg/kg/day) or greater for 10 days during gestation (pregnancy). The submitted 2-generation reproduction study using laboratory rats indicates dose-related decreases in parental and pup body weight and pup mortality at the parent's dietary intake levels which exceeded 10 ppm (MRID 00015301 and 41158101).

4.2.4. Toxicity to Terrestrial Invertebrates

Diazinon is categorized as highly toxic (defined as: LD_{50} <2 µg a.i./bee) to honey bees and other beneficial insects on an acute contact basis. Data are also available for an acute oral exposure of honey bees to technical grade diazinon. The resulting oral LD_{50} is 0.2 µg a.i./bee (MRID 05004151), which is consistent with the acute contact exposure value.

4.2.5. Toxicity to Terrestrial Plants

For Tier II seedling emergence tests, carrot is the most sensitive dicot (EC_{25} = 9.03 lbs a.i./A) and oat is the most sensitive monocot (EC_{25} = 5.26 lbs a.i./A). For Tier II vegetative vigor tests, cucumber is the most sensitive dicot (EC_{25} = 3.23 lbs a.i./A) and onion is the most sensitive monocot (EC_{25} = >7.0 lbs a.i./A).

4.3. Discussion of Degradate Toxicity

With respect to the diazinon degradate, oxypyrimidine, it is assumed that it is of lesser toxicity as compared to the parent compound. Comparison of available toxicity information for oxypyrimidine (**Table 33**) indicates lesser aquatic toxicity than the parent for freshwater fish, invertebrates, and aquatic plants. Specifically, the available degradate toxicity data for oxypyrimadine indicate that it is practically nontoxic to freshwater fish (rainbow trout 96-hr LC_{50}>101 mg a.i./L) (MRID 463643-12; Grade 1993a) and invertebrates (48-hr EC_{50}>102 mg a.i./L) (MRID 463643-13; Grade 1993b) with no mortality at the maximum concentrations tested. In addition, available aquatic plant degradate toxicity data for oxypyrimidine indicate that oxypyrimidine is practically nontoxic to nonvascular aquatic plants (green algae) with non-definitive EC_{50} values (EC_{50}>109 mg a.i./L) (Grade 1993c; MRID 463643-14) at concentrations 29 times higher than the lowest reported aquatic plant EC_{50} value for parent diazinon.

Table 33. Acute and subacute toxicity values for terrestrial and aquatic animals exposed to diazinon, diazoxon or oxypyrimidine.

Species	Diazinon		Diazoxon		Oxypyrimidine	
	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet	Acute Oral mg/kg bw	Subacute Dietary mg/kg diet
Bobwhite Quail	5.2 (Fink 1972)	245 (Hill *et al.* 1975)	4.99 (Rodgers 2005e)	72.3 (Rodgers 2005f)	>2060 (Rodgers 2005d)	>4910 (Rodgers 2005c)
Mallard Duck	1.44 (Fletcher and Pederson 1988)	32 (Fletcher and Pederson 1988)	--* (Rodgers 2005h)	104 (Rodgers 2005g)	--* (Rodgers 2005b)	>4990 (Rodgers 2005a)
Rainbow Trout	0.09 mg/L (Johnson and Finley 1980)	NA	no data	NA	>101 (Grade 1993a)	NA
Water flea	0.00021 mg/L (Banks 2005)	NA	no data	NA	>102 (Grade 1993b)	NA
Green algae	3.7 mg/L (Hughes1988)	NA	no data	NA	>109 (Grade 1993c)	NA

*mallard ducks regurgitated the test solution therefore dosage is unknown.
NA= not applicable

Similarly, oxypyrimidine was practically nontoxic to birds on an acute oral and subacute dietary exposure basis (**Table 33**) and was, once again, orders of magnitude less toxic than the parent to birds. Therefore, given the lesser toxicity of oxypyrimidine to both terrestrial and aquatic animals, as compared to the parent, concentrations of this degradate are not assessed.

With respect to the intermediate degradate diazoxon, acute and subacute toxicity testing with birds indicate that the compound is minimally as toxic (LD_{50}=4.99 mg a.i./kg bw) (Rodgers 2005e ; MRID 465796-04) as the parent (LD_{50}= 5.2 mg a.i./kg bw) on an acute oral exposure basis and is more toxic (LC_{50} = 72 mg a.i./kg diet) (Rodgers 2005f; MRID 465796-02) than the parent (LC_{50}=245 mg a.i./kg diet) on a subacute dietary exposure basis (**Table 33**). Toxicity testing with aquatic-phase amphibians indicates that diazoxon (96-hr LC_{50}=0.76 mg/L) is an order of magnitude more toxic than the parent compound (96-hr LC_{50}=7.49 mg/L) (Sparling and Fellars 2007). **Appendix A** contains more detailed descriptions of studies assessing the toxicities of oxypyrimidine and diazoxon to aquatic and terrestrial organisms.

5. Risk Characterization

Risk characterization is the integration of the exposure and effects characterizations to determine the potential ecological risk from varying diazinon use scenarios within the action area and likelihood of direct and indirect effects on the CRLF. The risk characterization provides estimation and description of the likelihood of adverse effects; it articulates risk assessment assumptions, limitations, and uncertainties; and synthesizes an overall conclusion regarding the effects determination (*i.e.*, "no effect," "likely to adversely affect," or "may affect, but not likely to adversely affect") for the CRLF.

5.1. Risk Estimation

Risk is estimated by calculating the ratio of exposure to toxicity. This ratio is the risk quotient (RQ), which is then compared to pre-established acute and chronic levels of concern (LOCs) for each category evaluated (**Appendix G**). For acute exposures to the CRLF and its animal prey in aquatic habitats, as well as terrestrial invertebrates, the LOC is 0.05. For acute exposures to the CRLF and mammals, the LOC is 0.1. The LOC for chronic exposures to CRLF and its prey, as well as acute exposures to plants is 1.0. As discussed in the analysis plan of the problem formulation (specifically, section 2.10.1.3), the non-listed LOC value for acute exposures to animal prey, which is 0.5, is also used for evaluating RQs.

Screening-level RQs are based on the most sensitive endpoints and modeled EECs in **aquatic systems** from the following scenarios for diazinon:

- Almond use @ 3 lbs a.i./A; 1 application per year (foliar or dormant)
- Blueberry use @ 1 pound a.i./A; 2 applications per year (1 application for fire ant treatment and 1 for foliar applications)
- Caneberry use @ 2 lbs a.i./A; 1 application per year (foliar)
- Colecrop, leafy vegetable, melon, root crop, row crop, tomato and tuber crop use @ 4 lbs a.i./A; 1 application per year (soil incorporation)
- Fig use @ 0.5 lbs a.i./A; 1 application per year (assumed foliar)
- Lettuce use @ 2 lbs a.i./A; 2 applications per *season* (1 soil incorporation and 1 foliar); aerial methods are permitted for this use only; although more than one season is possible for lettuce for 1 year, they are not modeled, due to model (PRZM) limitations
- Outdoor ornamental use @ 1 lb a.i./A; 1 application per *crop* (foliar); assumed that 26 seasons per year are possible
- Strawberry use @ 1 lb a.i./A; 2 applications per year (1 soil incorporation and 1 foliar)
- Tree fruit use @ 2 lbs a.i./A; 2 applications per year (1 foliar and 1 dormant)

For developing RQs for the **terrestrial**-phase CRLF and its prey (*e.g.* terrestrial insects, small mammals and terrestrial-phase frogs), exposures to diazinon resulting from foliar applications of diazinon are modeled. These include applications to almonds, blueberries, caneberries, fig, lettuce, melons, outdoor ornamentals, strawberries and tree fruit. Maximum application rates and numbers of application for each crop were modeled according to the list above. Only foliar applications are modeled, since T-REX is not appropriate for modeling soil applications with incorporation. Therefore, uses of diazinon on colecrops, leafy vegetables, root crops, row crops, tomatoes and tuber crops, which involve only soil incorporation, where not considered in the assessment of diazinon exposure to the terrestrial-phase CRLF and its prey in the terrestrial habitat since exposure is considered *deminimus*.

Exposures of terrestrial plants inhabiting dry and semi-aquatic habitats, single maximum applications of each use were modeled, including applications involving foliar and soil-incorporation methods. Maximum application rates were modeled using the list above.

5.1.1. Exposures in the Aquatic Habitat

5.1.1.1. Direct Effects to CRLF

For assessing acute risks of direct effects to the CRLF, 1-in-10 year peak EECs in the standard pond are used with the lowest acute toxicity value for fish. For chronic risks, 1-in-10 year peak 60-day EECs and the lowest chronic toxicity value for fish are used.

Resulting RQs exceed the acute risk to listed species LOC (RQ≥0.05) for applications to almonds, colecrops, leafy vegetables lettuce, melons, outdoor ornamentals, root crops, row crops, strawberries, tomatoes, tree fruit, and tuber crops. RQs do not exceed the acute risk LOC for applications to blueberries, caneberries, or figs. RQs exceed the chronic risk LOC (RQ≥1.0) for all uses except fig (**Table 34**).

If acute RQ values had been based on available amphibian data, *i.e.*, 96-hr LC_{50}=7,488 µg/L, rather than the most sensitive freshwater fish 96-hr LC_{50} value of 90 µg/L, none of the RQ values would have exceeded the acute risk to listed species LOC. Even if all of the diazinon was assumed to be present in the form of diazoxon and based on amphiban data for diazoxon (96-hr LC_{50}=760 µg/L), only three of the uses evaluated, *i.e*, soil incorporation for leaf vegetables, foliar applications (2) to lettuce and applications (26) to outdoor ornamentals, exceed the acute risk to listed species LOC.

Table 34. Risk Quotient values for acute and chronic exposures directly to the CRLF in aquatic habitats.

Uses	Application # and type	Peak EEC (µg/L)	60 day EEC (µg/L)	Direct effects, Acute RQ	Direct effects, Chronic RQ
Almonds	1 dormant	16	8.8	**0.17**	**16**
	1 foliar	9.1	5.4	**0.10**	**9.8**
Blueberries	2 foliar	2.6	1.5	0.03	**2.8**
	1 foliar	1.5	0.85	0.02	**1.6**
	1 fire ant	1.4	0.84	0.02	**1.5**
Caneberries	1 foliar	3.0	1.7	0.03	**3.1**
Cole crops[1]	1 soil incorp	24	17	**0.27**	**31**
Fig	1 foliar	0.63	0.39	0.01	0.70
Leafy vegetables[2]	1 soil incorp	55	35	**0.61**	**64**
Lettuce	2 aerial foliar	59	43	**0.66**	**78**
	1 soil incorp	27	18	**0.30**	**32**
	1 aerial foliar	31	19	**0.34**	**34**
Melons[3]	2 foliar	4.9	3.3	**0.05**	**6.0**
	1 soil incorp	3.3	1.9	0.04	**3.5**
	1 foliar	2.5	1.3	0.03	**2.4**
Outdoor ornamentals	26 foliar	50	34	**0.55**	**62**
	1 foliar	6.8	4.5	**0.08**	**8.2**
Root crops[4]	1 soil incorp	12	6.5	**0.13**	**12**
Row crops[5]	1 soil incorp	16	10	**0.18**	**18**
strawberries	2 foliar	27	18	**0.30**	**33**
	1 soil incorp	11	6.7	**0.13**	**12**
	1 foliar	21	14	**0.24**	**25**
Tomatoes	1 soil incorp	10	6.6	**0.12**	**12**
Tree fruit[6]	1 foliar + 1 dormant	6.7	3.3	**0.07**	**6.0**
	1 dormant	7.2	4.2	**0.08**	**7.6**
	1 foliar	2.5	1.5	0.03	**2.8**
Tuber crops[7]	1 soil incorp	11	6.8	**0.13**	**12**

[1] Specifically: broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens
[2] Specifically: spinach, endive
[3] Specifically: cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons
[4] Specifically: onion, radishes
[5] Specifically: carrots, beans, peppers (bell and chili), peas (succulent), beets (red)
[6] Specifically: apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes
[7] Specifically: rutabagas, sweet potatoes

5.1.1.2 Indirect Effects to CRLF through effects to prey

For assessing risks of indirect effects of diazinon to the aquatic-phase CRLF (tadpoles) through effects to its diet, 1-in-10 year peak EECs from the standard pond are used with the lowest acute toxicity value for aquatic unicellular plants to derive RQs. Resulting RQs do not exceed the acute risk LOC (RQ≥1.0) for aquatic plants from diazinon applications to any of the uses modeled (**Table 35**).

For assessing risks of indirect acute effects to the aquatic-phase CRLF through effects to prey (invertebrates) in aquatic habitats, 1-in-10 year peak EECs in the standard pond are used with the lowest acute toxicity value for invertebrates. For chronic risks, 1-in-10 year peak 21-day EECs and the lowest chronic toxicity value for invertebrates are used to derive RQs. Acute and chronic RQs exceed the acute LOCs for non-listed and listed species (RQ≥0.5 and RQ≥0.05, respectively) as well as the chronic LOCs for non-listed and listed species (RQ≥1.0) for single applications to all crops (**Table 36**).

Fish and frogs also represent prey of CRLF. These RQs are represented by those used for direct effects to the CRLF in aquatic habitats (**Table 34**). These RQs exceed the acute risk LOC for listed species (0.05) for applications to almonds, colecrops, leafy vegetables lettuce, melons, outdoor ornamentals, root crops, row crops, strawberries, tomatoes, tree fruit, and tuber crops. These RQs only exceed the acute risk LOC for non-listed species (0.5) for applications to leafy vegetables lettuce, and outdoor ornamentals. RQs do not exceed the acute risk LOC for listed or non-listed species for applications to blueberries, caneberries, or figs. RQs exceed the chronic risk LOC (1.0) for all uses except fig.

Table 35. Risk Quotient (RQ) values for exposures to unicellular aquatic plants (diet of CRLF in tadpole life stage).

Uses	Application # and type	Peak EEC (µg/L)	Indirect effects RQ (habitat)
Almonds	1 dormant	16	0.24
	1 foliar	9.1	0.14
Blueberries	2 foliar	2.6	0.04
	1 foliar	1.5	0.023
	1 fire ant	1.4	0.022
Caneberries	1 foliar	3.0	0.045
Cole crops[1]	1 soil incorp	24	0.37
Fig	1 foliar	0.63	0.010
Leafy vegetables[2]	1 soil incorp	55	0.83
Lettuce	2 aerial foliar	59	0.90
	1 soil incorp	27	0.42
	1 aerial foliar	31	0.47
Melons [3]	2 foliar	4.9	0.075
	1 soil incorp	3.3	0.050
	1 foliar	2.5	0.038
Outdoor ornamentals	26 foliar	50	0.76
	1 foliar	6.8	0.10
Root crops [4]	1 soil incorp	12	0.18
Row crops [5]	1 soil incorp	16	0.25
Strawberries	2 foliar	27	0.40
	1 soil incorp	11	0.17
	1 foliar	21	0.32
Tomatoes	1 soil incorp	10	0.16
Tree fruit [6]	1 foliar + 1 dormant	6.7	0.10
	1 dormant	7.2	0.11
	1 foliar	2.5	0.038
Tuber crops [7]	1 soil incorp	11	0.17

[1] Specifically: broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens

[2] Specifically: spinach, endive

[3] Specifically: cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons

[4] Specifically: onion, radishes

[5] Specifically: carrots, beans, peppers (bell and chili), peas (succulent), beets (red)

[6] Specifically: apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes

[7] Specifically: rutabagas, sweet potatoes

Table 36. Risk Quotient (RQ) values for acute and chronic exposures to aquatic invertebrates (prey of CRLF juveniles and adults) in aquatic habitats.

Uses	Application # and type	Peak EEC (µg/L)	21-day EEC (µg/L)	Indirect Effects Acute RQ	Indirect Effects Chronic RQ
Almonds	1 dormant	16	12	**74**	**70**
	1 foliar	9.1	7.3	**43**	**43**
Blueberries	2 foliar	2.6	2.1	**12**	**13**
	1 foliar	1.5	1.2	**7.1**	**7.1**
	1 fire ant	1.4	1.2	**6.8**	**7.0**
Caneberries	1 foliar	2.98	2.4	**14**	**14**
Cole crops[1]	1 soil incorp	24	20	**115**	**116**
Fig	1 foliar	0.63	0.52	**3.0**	**3.1**
Leafy vegetables[2]	1 soil incorp	55	47	**261**	**275**
Lettuce	2 aerial foliar	59	51	**283**	**302**
	1 soil incorp	27	23	**130**	**137**
	1 aerial foliar	31	25	**147**	**147**
Melons [3]	2 foliar	4.9	3.8	**23**	**23**
	1 soil incorp	3.3	2.6	**16**	**15**
	1 foliar	2.5	1.9	**12**	**11**
Outdoor ornamentals	26 foliar	50	41	**238**	**241**
	1 foliar	6.8	5.5	**32**	**33**
Root crops [4]	1 soil incorp	12	8.4	**58**	**50**
Row crops [5]	1 soil incorp	16	13	**78**	**78**
Strawberries	2 foliar	27	23	**126**	**138**
	1 soil incorp	11	8.8	**53**	**52**
	1 foliar	21	18	**102**	**107**
Tomatoes	1 soil incorp	10	8.8	**49**	**52**
Tree fruit [6]	1 foliar + 1 dormant	6.7	5.6	**32**	**33**
	1 dormant	7.2	6.1	**34**	**36**
	1 foliar	2.5	2.1	**12**	**12**
Tuber crops [7]	1 soil incorp	11	9.2	**54**	**54**

[1] Specifically: broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens
[2] Specifically: spinach, endive
[3] Specifically: cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons
[4] Specifically: onion, radishes
[5] Specifically: carrots, beans, peppers (bell and chili), peas (succulent), beets (red)
[6] Specifically: apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes
[7] Specifically: rutabagas, sweet potatoes

5.1.2.3. Indirect Effects to CRLF through effects to habitat (plants)

No data are available to assess the risks of diazinon to vascular aquatic plants. Given the lack of data, RQ values could not be derived to represent the risks of diazinon exposure to vascular aquatic plants. However, given that aquatic nonvascular plants and terrestrial plants are not particularly sensitive to diazinon, that aquatic mesocosm data did not reveal any effects to plants and that there are no incident reports on plants, it does not appear that diazinon is likely to affect aquatic vascular plants to the point that CRLF habitat would be adversely affected.

5.1.2. Exposures in the Terrestrial Habitat

5.1.2.1. Direct Effects to CRLF

As described above, to assess risks of diazinon to terrestrial-phase CRLF, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. Acute, subacute and chronic effects are estimated using the lowest available toxicity data for birds. EECs are divided by toxicity values to estimate acute and chronic dietary-based RQs as well as dose-based RQs. Acute, dietary-based RQ values, dietary-based chronic RQ values and dose-based RQ values exceed the LOC for listed species for all uses (**Table 37**).

Table 37. Acute and chronic, dietary-based RQs and dose-based RQs for direct effects to the terrestrial-phase CRLF.

Use	Dietary -Based, acute RQ	Dietary-based, chronic RQ	Acute Dose-Based RQ
Almonds	**13**	**49**	**64**
Blueberries	**4.2**	**16**	**21**
Caneberries	**8.4**	**33**	**42**
Fig	**2.1**	**8.1**	**11**
lettuce	**8.4**	**33**	**42**
Melons	**17**	**65**	**85**
outdoor ornamentals (26 aps)	**5.0**	**19**	**25**
outdoor ornamentals (1 ap)	**4.2**	**16**	**21**
strawberries	**4.2**	**16**	**21**
Tree fruit	**8.4**	**33**	**42**

Based on available data, terrestrial-phase amphibians are relatively insensitive to diazinon with an LD_{50} greater than 2000 mg/kg for bullfrogs. Additionally, available toxicity data indicate that diazoxon has similar toxicity to Bobwhite quail (LD_{50}=4.99 mg a.i./L) as that of the parent (LD_{50}=5.2 mg a.i./L). If acute dose-based RQ values had been based on the toxicity to terrestrial-phase amphibians, none of the RQs would exceed the acute risk to endangered species LOC.

5.1.2.2. Indirect Effects to CRLF through effects to prey

In order to assess the risks of foliar applications of diazinon to terrestrial invertebrates, which are considered prey of CRLF in terrestrial habitats, the honey bee is used as a surrogate for terrestrial invertebrates. The toxicity value for terrestrial invertebrates is calculated by multiplying the lowest available acute contact LD_{50} of 0.22 µg a.i./bee by 1 bee/0.128g, which is based on the weight of an adult honey bee. EECs (µg a.i./g of bee) calculated by T-REX for small and large insects are divided by the calculated toxicity value for terrestrial invertebrates, which is 1.72 µg a.i./g of bee. The resulting RQ values for large insect and small insect exposures bound the potential range of exposures for terrestrial insects to diazinon. For all uses, RQ values exceed the LOC (RQ≥0.05) for both large and small terrestrial insects (**Table 38**).

Table 38. Indirect effects to the terrestrial-phase CRLF through effects to potential prey items (terrestrial invertebrates).

Use	Small Insect RQ	Large Insect RQ
Almonds	**236**	**26**
Blueberries	**79**	**8.7**
Caneberries	**157**	**17**
Fig	**39**	**4.4**
Lettuce	**157**	**17**
Melons	**314**	**35**
outdoor ornamentals (26 aps)	**94**	**10**
outdoor ornamentals (1 ap)	**79**	**8.7**
Strawberries	**79**	**8.7**
Tree fruit	**157**	**17**

As described above, to assess risks of diazinon to prey (small mammals) of larger terrestrial-phase CRLF, dietary-based and dose-based exposures modeled in T-REX for a small mammal (15g) consuming small invertebrates are used. Acute, subacute and chronic effects are estimated using the most sensitive mammalian toxicity data. EECs are divided by the toxicity value to estimate acute and chronic dietary-based RQs as well as acute dose-based RQs. For all uses except figs, acute RQ values exceed the acute risk to listed species LOC (RQ≥0.1) and chronic dose-based and dietary-based RQ values exceed the chronic risk LOC (RQ≥1.0) for mammals considered as potential prey species for CRLF (**Table 39**).

Table 39. Acute and chronic, dose-based RQs and chronic dietary-based RQs for prey items (small mammals) of terrestrial-phase CRLF.

Use	Dose-based, acute RQ	Dose-based chronic RQ	Dietary -based, chronic RQ
Almonds	**0.35**	**625**	**72**
Blueberries	**0.12**	**208**	**24**
Caneberries	**0.24**	**416**	**48**
Fig	**0.06**	**104**	**12**
Lettuce	**0.24**	**416**	**48**
Melons	**0.47**	**833**	**96**
outdoor ornamentals (26 aps)	**0.14**	**248**	**29**
outdoor ornamentals (1 ap)	**0.12**	**208**	**24**
Strawberries	**0.12**	**208**	**24**
Tree fruit	**0.24**	**416**	**48**

An additional prey item of the adult CRLF is other species of frogs. In order to assess risks to these organisms, dietary-based and dose-based exposures modeled in T-REX for a small bird (20g) consuming small invertebrates are used. These are the same EECs, toxicity values and RQs used to assess direct effects to the CRLF. Acute, dietary-based RQ values, dietary-based chronic RQ values and dose-based RQ values exceed the LOC for listed species for all uses (**Table 37**). However, as discussed earlier, had acute RQ values been based on the limited toxicity data for terrestrial-phase amphibians, none of the RQ values would have exceeded the acute risk LOC.

5.1.2.3. Indirect Effects to CRLF through effects to habitat (plants)

For monocot and dicot plants inhabiting dry and semi-aquatic areas, the LOC (RQ≥1.0) is not exceeded for exposures resulting from single applications of any of the uses of diazinon (**Tables 40** and **41**).

Table 40. RQs for monocots inhabiting dry and semi-aquatic areas exposed to diazinon through runoff and drift.

Use	Application rate (lbs a.i./A)	Application method	Spray drift RQ (lbs a.i./A)	Dry area RQ (lbs a.i./A)	Semi-aquatic area RQ (lbs a.i./A)
Almonds	3	Foliar/dormant	<0.1	0.14	<0.1
Blueberries	1	Foliar/ground (fire ant)	<0.1	<0.1	<0.1
Caneberries	2	Foliar	<0.1	<0.1	<0.1
Colecrops	4	Soil incorporation	<0.1	<0.1	<0.1
Fig	0.5	Foliar	<0.1	<0.1	<0.1
Leafy vegetables	4	Soil incorporation	<0.1	<0.1	<0.1
lettuce	2	Soil incorporation	<0.1	<0.1	<0.1
	2	Foliar	<0.1	<0.1	<0.1
Melons	4	foliar	<0.1	0.16	<0.1
	4	Soil incorporation	<0.1	<0.1	<0.1
outdoor ornamentals	1	foliar	<0.1	<0.1	<0.1
Root crops	4	Soil incorporation	<0.1	<0.1	<0.1
Row crops	4	Soil incorporation	<0.1	<0.1	<0.1
strawberries	1	Foliar	<0.1	<0.1	<0.1
	1	Soil incorporation	<0.1	<0.1	<0.1
Tomatoes	4	Soil incorporation	<0.1	<0.1	<0.1
Tree fruit	2	foliar	<0.1	<0.1	<0.1
Tuber crops	4	Soil incorporation	<0.1	<0.1	<0.1

Table 41. RQs for dicots inhabiting dry and semi-aquatic areas exposed to diazinon through runoff and drift.

Use	Application rate (lbs a.i./A)	Application method	Spray drift RQ (lbs a.i./A)	Dry area RQ (lbs a.i./A)	Semi-aquatic area RQ (lbs a.i./A)
Almonds	3	Foliar/dormant	<0.1	<0.1	<0.1
Blueberries	1	Foliar/ground (fire ant)	<0.1	<0.1	<0.1
Caneberries	2	Foliar	<0.1	<0.1	<0.1
Colecrops	4	Soil incorporation	<0.1	<0.1	<0.1
Fig	0.5	Foliar	<0.1	<0.1	<0.1
Leafy vegetables	4	Soil incorporation	<0.1	<0.1	<0.1
Lettuce	2	Soil incorporation	<0.1	<0.1	<0.1
	2	Foliar	<0.1	<0.1	<0.1
Melons	4	Foliar	<0.1	<0.1	<0.1
	4	Soil incorporation	<0.1	<0.1	<0.1
Outdoor ornamentals	1	Foliar	<0.1	<0.1	<0.1
Root crops	4	Soil incorporation	<0.1	<0.1	<0.1
Row crops	4	Soil incorporation	<0.1	<0.1	<0.1
Strawberries	1	Foliar	<0.1	<0.1	<0.1
	1	Soil incorporation	<0.1	<0.1	<0.1
Tomatoes	4	Soil incorporation	<0.1	<0.1	<0.1
Tree fruit	2	Foliar	<0.1	<0.1	<0.1
Tuber crops	4	Soil incorporation	<0.1	<0.1	<0.1

5.2. Risk Description

The risk description synthesizes an overall conclusion regarding the likelihood of adverse impacts leading to an effects determination (*i.e.*, "no effect," "may affect, but not likely to adversely affect," or "likely to adversely affect") for the CRLF.

If the RQs presented in the Risk Estimation (**Section 5.1**) show no indirect effects and LOCs for the CRLF are not exceeded for direct effects, a "no effect" determination is made, based on use of diazinon within the action area. If, however, indirect effects are anticipated and/or exposure exceeds the LOCs for direct effects, the Agency concludes a preliminary "may affect" determination for the CRLF. Following a "may affect" determination, additional information is considered to refine the potential for exposure at the predicted levels based on the life history characteristics (*i.e.*, habitat range, feeding preferences, etc.) of the CRLF and potential community-level effects to aquatic plants. Based on the best available information, the Agency uses the refined evaluation to distinguish those actions that "may affect, but are not likely to adversely affect" from those actions that are "likely to adversely affect" the CRLF.

The criteria used to make determinations that the effects of an action are "not likely to adversely affect" the CRLF include the following:

- Significance of Effect: Insignificant effects are those that cannot be meaningfully measured, detected, or evaluated in the context of a level of effect where "take" occurs for even a single individual. "Take" in this context means to harass or harm, defined as the following:

    - Harm includes significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering.

    - Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

- Likelihood of the Effect Occurring: Discountable effects are those that are extremely unlikely to occur. For example, use of dose-response information to estimate the likelihood of effects can inform the evaluation of some discountable effects.

- Adverse Nature of Effect: Effects that are wholly beneficial without any adverse effects are not considered adverse.

Table 42 summaries the effects determinations for the CRLF. A description of the risk and effects determination for each of the established assessment endpoints for the CRLF is provided in the following sections. **Table 43** summarizes the effects determinations for the critical habitat.

Table 42. Diazinon Effects Determination Summary for the CRLF.

Assessment Endpoint	Exposure (duration, habitat)	Effects Determination[1]	Basis for Determination
Direct effects to CRLF	Acute, aquatic	LAA[2]	- Acute LOC is exceeded for most uses (all but fig, blueberries, and caneberries) based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data. - At the highest estimated concentration of diazinon in water (resulting from use on lettuce), the likelihood of individual mortality is 1 in 5. - Maximum observed concentrations of diazinon in surface waters are sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic vertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to ≤55% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all but 1 use (fig) based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses (almonds, blueberries, caneberries, fig, lettuce, melons, outdoor ornamentals, strawberries and tree fruit); based on the most sensitive surrogate bird data. - Refined estimates of exposure based on CRLF-specific diet considerations result in LOC exceedances for dose-based and dietary-based exposures.
	Chronic, terrestrial	LAA	- Chronic LOC is exceeded for all foliar uses based on the most sensitive surrogate bird data. - Refined estimates of exposure based on CRLF-specific diet considerations result in LOC exceedances for dietary-based exposures.
Indirect effects to tadpole CRLF via reduction of prey (*i.e.*, algae)	Aquatic	NE	- LOC is not exceeded for any uses of diazinon.
Indirect effects to juvenile and adult CRLF via reduction of prey (*i.e.*, invertebrates)	Acute, aquatic	LAA	- Acute LOC is exceeded for all uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate invertebrate data. - Estimated concentrations of diazinon in water resulting from all uses result in a likelihood of individual mortality of 100%. - Of the NAWQA monitoring data from California surface waters with agricultural watersheds, 51% of samples contained concentrations of diazinon that were sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic invertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to >70% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate invertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses based on the most sensitive surrogate terrestrial invertebrate data.

Indirect effects to adult CRLF via reduction of prey (*i.e.*, fish, frogs, mice)	Acute, aquatic	LAA	- Acute LOC is exceeded for several uses based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data. - At the highest estimated concentration of diazinon in water (resulting from use on lettuce), the likelihood of individual mortality is 1 in 5. - Maximum observed concentrations of diazinon in surface waters are sufficient to exceed the LOC. - Consideration of species sensitivity distributions for aquatic vertebrates and estimated exposure concentrations for diazinon uses indicates that there is risk to ≤55% of species.
	Chronic, aquatic	LAA	- Chronic LOC is exceeded for all but 1 use based on estimated concentrations of diazinon in water and on the most sensitive surrogate vertebrate data.
	Acute, terrestrial	LAA	- Acute LOC is exceeded for all foliar uses based on the most sensitive surrogate amphibian data. - Refined estimates of exposure based on amphibian-specific diet considerations result in LOC exceedances for dietary-based and dose-based exposures. - For foliar uses, effects determination based on acute effects to mice is NLAA.
	Chronic, terrestrial	LAA	- Chronic LOC is exceeded for all foliar uses based on the most sensitive surrogate mammalian and amphibian data. - Refined estimates of exposure based on amphibian-specific diet considerations result in LOC exceedances for dietary-based exposures.
Indirect effects to CRLF via reduction of habitat and/or primary productivity (*i.e.*, plants)	Aquatic	NE	- Diazinon use does not directly affect non-vascular aquatic plants or vascular terrestrial plants. Estimated EECs for all modeled diazinon use scenarios within the action area are well below the threshold concentration for aquatic, non-vascular plants as well as terrestrial plants inhabiting semi-aquatic or terrestrial areas. - Although there are no toxicity data for aquatic vascular plants, the data for nonvascular aquatic plants and vascular terrestrial plants, the lack of any reported field incidents involving plants, and mesocosm data indicating that plants were not affected indicate that plants are less sensitive to diazinon than animals. In addition, plants are not likely to be affected by diazinon's mode of action.
	Terrestrial	NE	

[1]LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect
[2]Although a number of uses exceed the acute risk LOC for listed species, it is possible that for at least some of these uses, the likelihood of individual mortality may be sufficiently low to arrive at a NLAA determination.

Table 43. Effects Determination Summary for the Critical Habitat Impact Analysis.

Assessment Endpoint	Effects Determination	Basis
Aquatic Phase PCEs (Aquatic Breeding Habitat and Aquatic Non-Breeding Habitat)		
Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.	No effect	Risk of diazinon to plants assumed to be negligible based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident.
Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.[1]	No effect	Risk of diazinon to plants assumed to be negligible based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident.
Alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source.	Habitat modification	RQs exceeded for acute and chronic effects to prey items (invertebrates, fish, aquatic phase amphibians)
Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)	No effect	No RQs for algae are exceeded
Terrestrial Phase PCEs (Upland Habitat and Dispersal Habitat)		
Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or dripline surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance	No effect	Based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident. Also, no RQs are exceeded for terrestrial plants exposed to diazinon.
Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal	No effect	Based on presumed low phytotoxicity, mode of action, and a history of application to various agricultural crops without incident. Also, no RQs are exceeded for terrestrial plants exposed to diazinon.
Reduction and/or modification of food sources for terrestrial phase juveniles and adults	Habitat modification	Diazinon poses acute and chronic risk to prey items of the CRLF (terrestrial invertebrates, mice, terrestrial-phase frogs).
Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.	Habitat modification	Diazinon poses acute and chronic risk to prey items of the CRLF (terrestrial invertebrates, mice, terrestrial-phase frogs).

[1]Physico-chemical water quality parameters such as salinity, pH, and hardness are not evaluated because these processes are not biologically mediated and, therefore, are not relevant to the endpoints included in this assessment.

5.2.1. Direct Effects

5.2.1.1. Aquatic-phase

All modeled uses except blueberries and figs exceed the acute risk to listed species LOC by factors ranging 1 to 13X for direct effects to aquatic-phase CRLF. All of the uses modeled except for figs exceed the chronic risk LOC for direct effects to the aquatic-phase CRLF; the chronic risk LOC is exceeded by factors ranging 1.5 – 78X. Thus, except for use on blueberries and figs, a "may affect" determination is made based on potential acute mortality of aquatic-phase amphibians; except for use on figs a "may affect" determination is made based on potential chronic effects (impaired survival) on aquatic-phase amphibians.

A source of uncertainty in the derivation of RQs is the estimation of exposure. As discussed above (section 3.1.1.4) concentrations of diazinon have been detected in California surface waters at levels sufficient to exceed the LOC for direct acute effects to the CRLF (>4.5µg/L). Therefore, both estimates and measures of diazinon in surface waters are at levels sufficient to potentially result in effects to the CRLF.

An analysis of the likelihood of individual direct mortality (**Appendix I**) indicates that based on the highest RQ value (0.66) for direct effects on the aquatic-phase CRLF and with a default dose response slope of 4.5, the likelihood is 1 in 5. Given that this RQ is based on exposure modeling representing applications of diazinon to lettuce for one season per year, and the potential for multiple seasons of lettuce crops per year, it is possible that the exposure is higher than estimated in this assessment. Therefore, the likelihood of individual effect could be greater than 1 in 5. At the listed species LOC, *i.e.*, RQ=0.05, the likelihood of individual mortality is 1 in 4.2×10^8 which is a relatively low likelihood of effect. Although many of the current uses are estimated to exceed the acute risk to listed species LOC for aquatic-phase CRLF, the likelihood of individual mortality may be relatively low for some of the uses. For example, at an RQ value of 0.2, the likelihood of individual mortality is 1 in 1,210 which still appears to be a relatively low likelihood; however, at an RQ of 0.3, the likelihood of individual mortality has increased to 1 in 107. At this point, there are insufficient data to determine a reasonable threshold for what constitutes a significant likelihood of individual direct effect; however, probabilities such as 1 in 4.2×10^8 and perhaps as great as 1 in 1,200 may be sufficiently low to discount the effect in which case, strawberries, outdoor ornamentals, lettuce, leafy vegetables and cole crops would be the only uses that an LAA determination would apply (**Table 44).**

Table 44. Likelihood of individual effect for each use of diazinon for the CRLF.

Use	Greatest RQ	Likelihood of Individual Effect (1 in …)
Almonds	0.17	3,165
Blueberries	0.03	-
Caneberries	0.03	-
Cole crops	0.27	199
Fig	0.01	-
Leafy vegetables	0.61	6
lettuce	0.66	<5
Melons	0.05	418,358,570
outdoor ornamentals	0.55	8
Root crops	0.13	29,921
Row crops	0.18	2,486
strawberries	0.3	107
tomatoes	0.12	58,519
Tree fruit	0.08	2,509,338
Tuber crops	0.13	29,921

The potential for diazinon to result in direct acute mortality of aquatic-phase CRLF is based on toxicity data for the most sensitive fish. However, if risk estimates were based on available acute amphibian toxicity data for diazinon, none of the RQ values would exceed the acute risk LOC and the determination would be that current uses of diazinon have "no effect" on the aquatic-phase CRLF. Similarly, had the assessment for indirect effects to CRLF based on adverse effects to its forage base of other frogs been based on amphibian toxicity data, a no effect determination would have been reached. Since the amphibian toxicity data (Sparling and Fellars 2006) are based on nominal rather than measured concentrations, the actual exposure concentration that result in a median lethal concentration is uncertain; therefore, the quantitative use of these data cannot be justified.

5.2.1.2. Terrestrial-phase

Both dietary-based and dose-based RQ values exceed the acute risk to listed species LOC for direct effects to terrestrial-phase CRLF across all of the foliar diazinon uses assessed (almonds, blueberries, caneberries, fig, lettuce, melons, outdoor ornamentals, strawberries and tree fruit); dose-based RQ values exceeded the acute risk LOC by factors ranging 110 to 850X (dose-based exposures). Similarly, across all of the foliar uses evaluated, the chronic risk LOC is exceeded by factors ranging between 8 to 65X. Thus, a "may affect" determination is made based on both potential direct acute risk (mortality) and chronic impaired survival of terrestrial-phase CRLF.

Although dietary-based RQ values are considerably lower than dose-based RQ values (**Table 37**), the former do not take into account that different sized animals consume differing amounts of food and that depending on the forage item, an animal has to consume varying amounts due to differing nutrition levels in the food item. If dietary-based RQ values are adjusted to account for differential food consumption, the adjusted RQ value would likely approximate the dose-based RQ value. With dose-based acute RQ values ranging 11 to 85, it is likely that terrestrial-phase CRLF foraging on small insects will be subject to acute mortality. Additionally, with chronic dietary-based RQ values ranging 8 to 65, terrestrial-phase CRLF foraging on small insects will be subject to chronic reductions in offspring survival.

Birds are currently used as surrogates for terrestrial-phase CRLF. However, amphibians are poikilotherms (body temperature varies with environmental temperature) while birds are homeotherms (temperature is regulated, constant, and largely independent of environmental temperatures). Therefore, amphibians tend to have much lower metabolic rates and lower caloric intake requirements than birds or mammals. As a consequence, birds are likely to consume more food than amphibians on a daily dietary intake basis, assuming similar caloric content of the food items. Therefore, the use of avian food intake allometric equation as a surrogate to amphibians is likely to result in an over-estimation of exposure and risk for reptiles and terrestrial-phase amphibians. Therefore, T-REX (version 1.3.1) has been altered to the T-HERPS model, which allows for an estimation of food intake for poikilotherms using the same basic procedure as T-REX to estimate avian food intake.

In order to explore influences of amphibian-specific food intake equations on potential dose-based and dietary-based exposures of the terrestrial-phase CRLF to diazinon, T-HERPS was used. Since applications of diazinon for all uses result in exposures sufficient to exceed the LOC for direct effects to the CRLF, the lowest application rate is used for T-HERPS to understand whether or not the minimum of the maximum application rates allowed by labels results in LOC exceedances. With T-REX, the lowest application rate of 0.5 lbs a.i./A, which corresponds to use on figs, results in dietary-based and dose-based EECs of 67.5 ppm and 76.88 mg/kg-bw, respectively. Dietary-based EECs for CRLF modeled using T-HERPS range 2.34-79.07 ppm, depending upon the food source. Dose-based EECs for CRLF modeled using T-HERPS range 0.73-2.62 mg/kg-bw (**Table 45**).

Table 45. Dietary-based and dose-based EECs relevant to direct effects to the CARLF through consumption of prey contaminated by diazinon applied to figs. Modeling done with T-HERPS

Food	Dietary Based EEC (ppm)	Dose Based EEC (mg/kg-bw) 1.4 g CRLF	Dose Based EEC (mg/kg-bw) 37 g CRLF	Dose Based EEC (mg/kg-bw) 238 g CRLF
Small Insects	67.5	2.62	2.58	1.69
Large Insects	7.5	0.29	0.29	0.19
Small Herbivore mammals	79.07	NA	74.8	11.63
Small Insectivore mammals	4.94	NA	4.67	0.73
Small Terrestrial Phase Amphibians	2.34	NA	0.09	0.06

Dietary-based and dose-based RQs for diazinon exposures from applications to figs exceed the LOC for direct effects to CRLF consuming small insects, large insects, small herbivore mammals, and small insectivore mammals. For acute, dietary-based exposures, RQs exceed the LOC (0.1) for CRLF consuming all food sources but small, terrestrial-phase amphibians. For chronic, dietary-based exposures, RQs exceed the chronic risk LOC (RQ≥1.0) for CRLF consuming small insects and small herbivore mammals. For dose-based exposures, the acute risk to listed species LOC (RQ≥0.1) is exceeded for CRLF consuming all types of food, except small terrestrial amphibians (**Table 46**). Since applications of diazinon to figs represent the lowest maximum application rates of all diazinon uses relevant to California, EECs and subsequent RQs resulting from other uses with higher application rates would be expected to be greater.

As stated previously though, available toxicity data suggest that terrestrial-phase amphibians are less sensitive to diazinon than the surrogate bird species used; had RQ values been calculated using the terrestrial-phase amphibian no acute risk LOCs would be exceeded for direct effects to terrestrial-phase CRLF for any of the uses. Additionally, based on the bullfrog toxicity data, no indirect effect RQ values for terrestrial-phase amphibians serving as prey would exceed the acute risk LOC.

Table 46. Acute and chronic, qualitative dietary-based RQs and dose-based RQs for direct effects to the terrestrial-phase CRLF, based on diazinon exposures resulting from applications to figs. RQs calculated using T-HERPS.

Food	Dietary Based Acute RQ	Dietary Based Chronic RQ	Dose Based RQ 1.4 g CRLF	Dose Based RQ 37 g CRLF	Dose Based RQ 238 g CRLF
Small Insects	**2.11**	**8.13**	**1.82**	**1.79**	**1.17**
Large Insects	**0.23**	0.9	**0.2**	**0.2**	**0.13**
Small Herbivore mammals	**2.47**	**9.53**	NA	**51.94**	**8.08**
Small Insectivore mammals	**0.15**	0.6	NA	**3.25**	**0.5**
Small Terrestrial-phase Amphibians	0.07	0.28	NA	0.06	0.04

NA = not applicable

An analysis of the likelihood of individual direct mortality (**Appendix I**) indicates that based on the dose-based RQ value for terrestrial-phase frogs consuming small insects (RQ=1.82) for direct effects on the aquatic-phase CRLF and with an acute oral dose-response slope of 2.92 (**Table 29**), the likelihood is roughly 100%. At the listed species LOC, *i.e.*, RQ=0.1, the likelihood of individual mortality is 1 in 570. Using dietary-based RQ values for terrestrial-phase CRLF feeding on small insects (RQ=2.11) and a subacute dietary dose-response slope of 5.6 (**Table 29**), the likelihood of individual mortality is 100%; however, with a subacute dietary dose-response slope of 5.6, the likelihood of individual effects at the listed species LOC is 1 in 9.3×10^7.

Similar to the discussion regarding the likelihood of direct effect to individual aquatic-phase CRLF, there is uncertainty regarding what constitutes a significant likelihood of an individual effect to terrestrial-phase CRLF. At the listed species LOC of 0.1 and based on the acute oral toxicity dose-response slope of 2.92, the likelihood of one animal dieing does not appear to be high (1 out of 570), but at an RQ value of 0.2, the likelihood of mortality increases to 1 in 48. Thus, it may be possible to discount potential indirect effects to small (1.4 g), intermediate (37 g) and large (238 g) terrestrial-phase frogs consuming large insects, based on dose-based RQ values for the lowest application rate to figs (**Table 46**) if the likelihood of individual effects is not considered significant. However, since application rates would be greater for other uses, the likelihood of individual effects for frogs consuming large insects would be expected to be greater and could potentially be of concern.

5.2.2. Indirect Effects (through effects to prey)

As discussed in section 2.5.3, the diet of CRLF tadpoles is composed primarily of unicellular aquatic plants and detritus. Based on RQs for algae (**Table 35**), applications of diazinon are not expected to affect this food source. Therefore, indirect effects of diazinon to CRLF tadpoles by reductions in phytoplankton are not expected based on the animal's diet during this life stage.

When CRLF reach juvenile and adult stages, the CRLF diet is composed of aquatic and terrestrial invertebrates, when in aquatic and terrestrial habitats, respectively. RQ values representing acute and chronic exposures to aquatic invertebrates and acute exposures to terrestrial invertebrates indicate that all uses of diazinon can potentially result in adverse effects to invertebrates. Therefore, indirect effects are possible to CRLF juveniles and adults, through decreases in prey, in both terrestrial and aquatic habitats. Based on an analysis of the likelihood of individual mortality using the highest RQ value for aquatic invertebrates (RQ=283) and a probit dose-response slope of 6.34, the likelihood of individual mortality is 100%. Even at the lowest RQ value, *i.e*, RQ=3, the likelihood of individual mortality is 100% (**Appendix I**).

A source of uncertainty in the derivation of RQs is the estimation of exposure. As discussed above (section 3.1.1), concentrations of diazinon have been frequently detected in California surface waters at levels sufficient to exceed the LOC for effects to aquatic invertebrates (>0.0105 µg/L). Concentrations have also been detected at levels sufficient to exceed the LOC for effects to aquatic vertebrates (>4.5 µg/L). Therefore, both estimates and measures of diazinon in surface waters are at levels sufficient to potentially result in indirect effects to the CRLF through acute effects to its prey (aquatic invertebrates, fish and frogs).

Life history data also indicate that large adult frogs consume aquatic and terrestrial vertebrates, including: fish, frogs and mice. RQ values representing direct exposures of diazinon to CRLF can also be used to represent exposures of diazinon to fish and frogs in aquatic habitats. Based on estimated exposures resulting from use of diazinon, acute and/or chronic risks to fish and frogs are possible for all uses, except fig (**Table 34**). RQs representing exposures of diazinon to mice (small mammals) and terrestrial-phase frogs (that are prey) indicate acute and chronic risks resulting from all foliar uses of diazinon. Therefore, indirect effects are possible to large CRLF adults, through decreases in prey, in both aquatic and terrestrial habitats.

Based on the highest dietary-based RQ (RQ=17) for terrestrial-phase amphibians, the likelihood of individual mortality is 100% (**Appendix I**). At the highest RQ for mammals (RQ=0.47), the likelihood of individual mortality is 1 in 14; at the listed species LOC of 0.1 the likelihood of individual mortality is 1 in 29,400; therefore, indirect effects through reductions in the number of mice is not likely to adversely affect the terrestrial-phase CRLF. However, dose-based and dietary-based chronic RQ values for mammals ranged between 12 -96 and 104 – 833, respectively. Even if chronic RQ values had been based on the LOAEC (100 ppb) rather than the NOAEC, the lowest chronic RQ would have exceeded the chronic risk LOC by a factor of

1.2X. Therefore, while the likelihood of individual acute effects to mammalian prey items may be low, the likelihood of chronic effects on mammalian prey could adversely [indirectly] affect the terrestrial-phase CRLF.

In order to explore influences of amphibian-specific food intake equations on potential dose-based and dietary-based exposures of amphibians (prey of CRLF) to diazinon, T-HERPS is used. Since applications of diazinon for all uses result in exposures sufficient to exceed the LOC for effects to amphibians representing prey of the CRLF, T-HERPS is used to model exposures resulting from the lowest maximum single application rate for diazinon, which is 0.5 lbs a.i./A, corresponding to use on figs. The Pacific tree frog is used to represent amphibian prey species. The weight of the animal is assumed to be 2.3 g, and its diet is assumed to be composed of small and large insects. For Pacific tree frogs consuming small and large insects, acute dietary-based exposures as well as dose based exposures of diazinon resulting from applications to fig are sufficient to exceed the LOC. When considering chronic risk, dietary-based exposures to the Pacific tree frog, the chronic risk LOC is exceeded for frogs consuming small insects but not those consuming large insects (**Table 47**). Since applications of diazinon to figs represent the lowest maximum application rates of all uses relevant to California, EECs and subsequent RQs resulting from other uses with higher application rates would be expected to be greater.

Table 47. Acute and chronic, qualitative dietary-based RQs and dose-based RQs for direct effects to amphibians serving as prey. Exposure modeling is based on diazinon exposures resulting from applications to figs. Effects to the prey result in indirect effects.

Food	Dietary Based EEC	Dose Based EEC	Dietary Based Acute RQ	Dietary Based Chronic RQ	Dose Based RQ
Small Insects	67.50	2.34	**2.11**	**8.13**[2]	**1.63**
Large Insects	7.50	0.26	**0.23**	0.90	**0.18**

5.2.3. Indirect Effects (through effects to habitat)

As discussed in section 2.5.4, the habitat of the CRLF varies during its life cycle, with the CRLF surviving in aquatic, riparian and upland areas. Adults rely on riparian vegetation for resting, feeding, and dispersal. Egg masses are typically attached to emergent vegetation, such as bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) or roots and twigs, and float on or near the surface of the water (Hayes and Miyamoto 1984).

Based on RQs for plants inhabiting dry and semi-aquatic habitats (**Tables 40 and 41**), applications of diazinon are not expected to affect these plants. There is uncertainty regarding the potential effect of diazinon on aquatic vascular plants due to a lack of effects data for these plants. However, the risk of diazinon to the CRLF through reduction of habitat is considered to be low based on the data available for aquatic nonvascular plants, vascular terrestrial plants and the lack of any reported field incidents involving plants. Additionally, mesocosm studies indicated that while aquatic invertebrates were affected at concentrations greater than 11 µg a.i./L, neither fish nor plants were affected even at the maximum concentration tested, i.e., 91.5 µg a.i./L. Therefore, indirect effects of diazinon to CRLF through effects to plants composing the riparian and terrestrial habitats are not expected.

5.2.4. Primary Constituent Elements of Designated Critical Habitat

5.2.4.1. Aquatic-Phase (Aquatic breeding habitat and aquatic non-breeding habitat)

Three of the four assessment endpoints for the aquatic-phase primary constituent elements (PCEs) of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- Alteration of channel/pond morphology or geometry and/or increase in sediment deposition within the stream channel or pond: aquatic habitat (including riparian vegetation) provides for shelter, foraging, predator avoidance, and aquatic dispersal for juvenile and adult CRLFs.
- Alteration in water chemistry/quality including temperature, turbidity, and oxygen content necessary for normal growth and viability of juvenile and adult CRLFs and their food source.
- Reduction and/or modification of aquatic-based food sources for pre-metamorphs (*e.g.,* algae)

Due to no RQ exceedances for unicellular, aquatic plants and for plants inhabiting semi-aquatic areas, diazinon use results on "no effect" to plants.

The remaining aquatic-phase PCE is "alteration of other chemical characteristics necessary for normal growth and viability of CRLFs and their food source." To assess the impact of diazinon on this PCE, acute and chronic freshwater fish and invertebrate toxicity endpoints are used as measures of effects. RQs for these endpoints exceed the LOC for all uses. Therefore, the determination for this endpoint is "habitat modification."

5.2.4.2. Terrestrial-Phase (upland habitat and dispersal habitat)

Similar to the aquatic-phase PCEs, three of the four assessment endpoints for the terrestrial-phase PCEs of designated critical habitat for the CRLF are related to potential effects to aquatic and/or terrestrial plants:

- Elimination and/or disturbance of upland habitat; ability of habitat to support food source of CRLFs: Upland areas within 200 ft of the edge of the riparian vegetation or drip line surrounding aquatic and riparian habitat that are comprised of grasslands, woodlands, and/or wetland/riparian plant species that provides the CRLF shelter, forage, and predator avoidance
- Elimination and/or disturbance of dispersal habitat: Upland or riparian dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal
- Alteration of chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.

Due to no RQ exceedances for plants inhabiting dry areas, diazinon use results on "no effect" to plants.

The remaining terrestrial-phase PCE is "reduction and/or modification of food sources for terrestrial phase juveniles and adults." To assess the impact of diazinon on this PCE, acute and chronic toxicity endpoints for terrestrial invertebrates, mammals, and terrestrial-phase frogs are used as measures of effects. RQs for these endpoints exceed the LOC for all foliar uses. Therefore, the determination for this endpoint is "habitat modification."

5.2.5. Action Area

5.2.5.1. Areas indirectly affected by the federal action

The initial action area for diazinon was previously discussed in Section 2.7 and depicted in **Figures 4** and **5** of the problem formulation. In order to determine the extent of the action area in lotic (flowing) aquatic habitats, the agricultural and orchard uses resulting in the greatest ratios of the RQ to the LOC for any endpoint for aquatic organisms is used to determine the distance downstream for concentrations to be diluted below levels that would be of concern (*i.e*. result in RQs above the LOC). For this assessment, the greatest ratio for an agricultural use is 5665, for indirect effects to the CRLF through acute effects to aquatic invertebrates exposed to diazinon in runoff from applications to lettuce. For an orchard crop, the greatest ratio is 1489, for indirect effects to the CRLF through acute effects to aquatic invertebrates exposed to diazinon in runoff from a single dormant season application of diazinon to almonds (**Table 48**). The areas indirectly affected by the federal action due to runoff of diazinon to aquatic habitats are depicted in **Figures 14 and 15**. The total stream kilometers within the action area that are at levels of concern are defined in **Table 49**.

Table 48. Risk Quotient to Level of Concern (RQ/LOC) ratios for direct and indirect effects of diazinon exposures to organisms in lotic aquatic habitats.

Use	Application # and type	Direct acute effects	Indirect Acute Effects (prey-inverts)	Indirect effects (tadpole prey/habitat-algae)	Direct Chronic effects	Indirect Chronic Effects (prey-inverts)
Agricultural Crops						
Blueberries	2 foliar	1	249	0	3	13
	1 foliar	0	142	0	2	7
	1 fire ant	0	136	0	2	7
Caneberries	1 foliar	1	284	0	3	14
Cole crops[1]	1 soil incorp	5	2295	0	31	116
Leafy vegetables[2]	1 soil incorp	12	5214	1	64	275
Lettuce	2 aerial foliar	13	**5665**	1	78	302
	1 soil incorp	6	2606	0	32	137
	1 aerial foliar	7	2938	0	34	147
Melons [3]	2 foliar	1	469	0	6	23
	1 soil incorp	1	316	0	4	15
	1 foliar	1	236	0	2	11
outdoor ornamentals	26 foliar	11	4753	1	62	241
	1 foliar	2	647	0	8	33
Root crops [4]	1 soil incorp	3	1153	0	12	50
Row crops [5]	1 soil incorp	4	1554	0	18	78
strawberries	2 foliar	6	2526	0	33	138
	1 soil incorp	2	1070	0	12	52
	1 foliar	5	2039	0	25	107
Tomatoes	1 soil incorp	2	982	0	12	52
Tuber crops [7]	1 soil incorp	3	1086	0	12	54
Orchard Crops						
Almonds	1 dormant	3	**1489**	0	16	70

	1 foliar	2	867	0	10	43
Fig	1 foliar	0	60	0	1	3
Tree fruit [6]	1 foliar + 1 dormant	1	638	0	6	33
	1 dormant	2	682	0	8	36
	1 foliar	1	241	0	3	12

[1] broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens

[2] spinach, endive

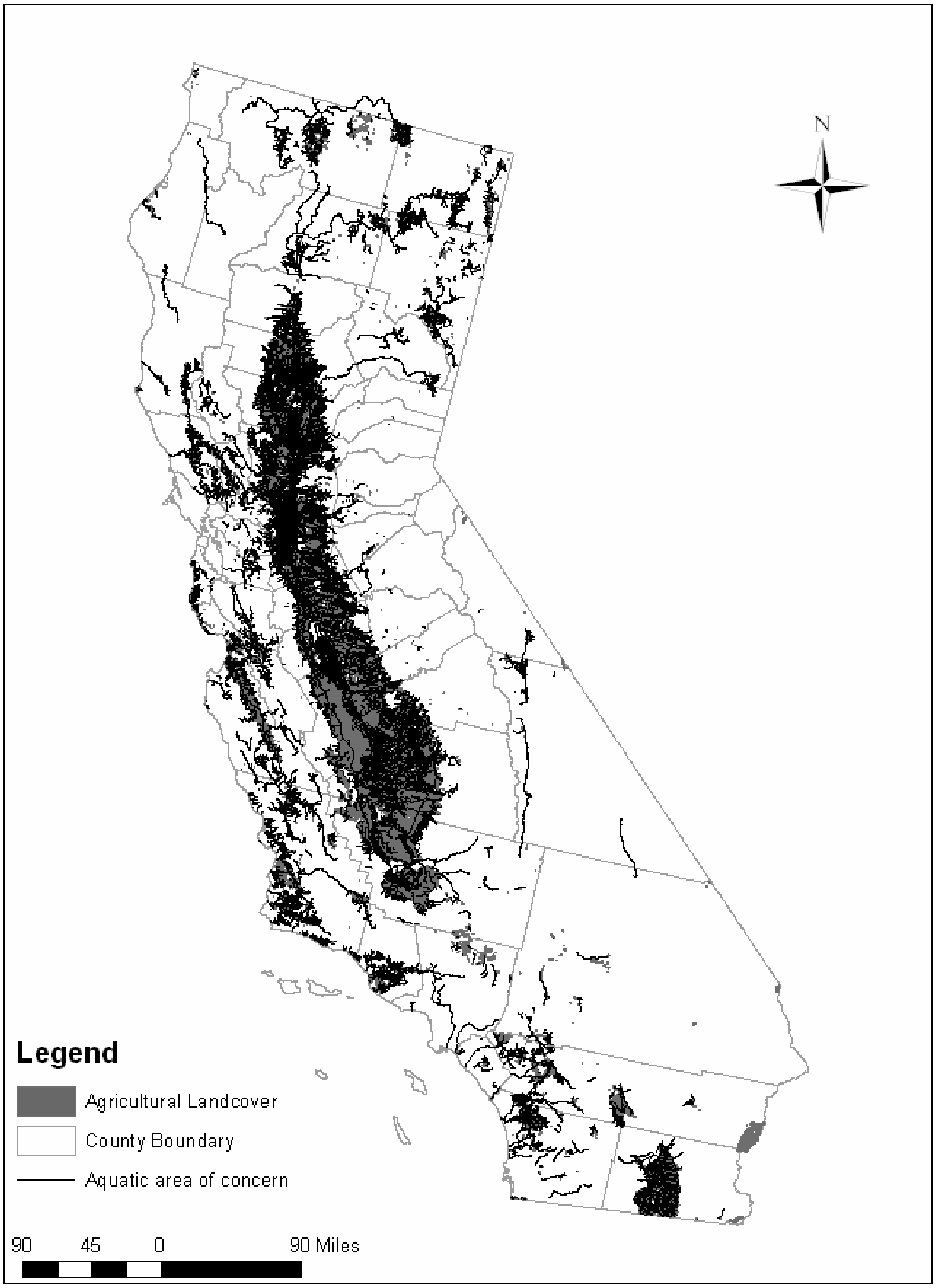
[3] cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons

[4] onion, radishes

[5] carrots, beans, peppers (bell and chili), peas (succulent), beets (red)

[6] apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes

[7] rutabagas, sweet potatoes



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by U.S. Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. April 11, 2007.
Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Figure 14. Downstream dilution map relevant to agricultural areas where diazinon is used. Areas potentially directly and indirectly affected by the federal action are depicted.

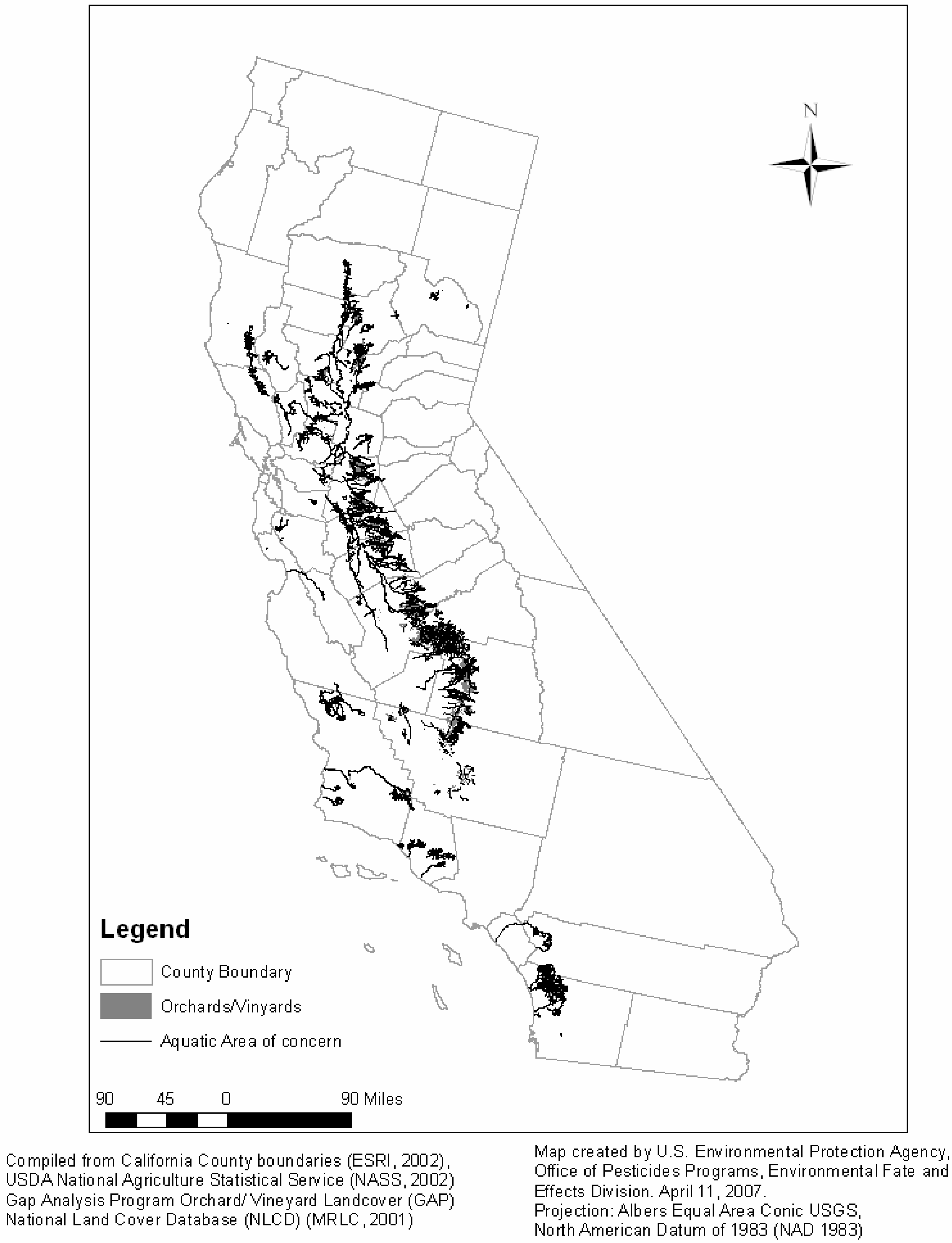


Figure 15. Downstream dilution map relevant to orchards where diazinon is used. Areas potentially directly and indirectly affected by the federal action are depicted.

Table 49. Quantitative results of spatial analysis of lotic aquatic action area relevant to diazinon.

Measure	Distance (km)	
	Agricultural Areas	Orchard Areas
Total Streams in CA	332,962	332,962
Streams within initial area of concern	57,087	11,945
Downstream distance added	20,027	3,522
Streams in aquatic action area	77,114	15,467

When considering the terrestrial habitats of the CRLF, spray drift from use sites onto non-target areas could potentially result in exposures of the CRLF, its prey and its habitat to diazinon. Therefore, it is necessary to estimate the distance from the application site where spray drift exposures do not result in LOC exceedances for organisms within the terrestrial habitat.

To account for this, first, the diazinon application rate which does not result in an LOC exceedance is calculated for each terrestrial taxa of concern (**Table 50**). The lowest application rate for terrestrial organisms (0.0005 lbs a.i./A), which is relevant to direct effects to CRLF through acute, dose-based exposures, is selected for determining the concentration of diazinon in spray drift that will not result in an LOC exceedance.

Table 50. Rate for single application of diazinon which does not exceed the LOC for the specified endpoint for organism in terrestrial habitat.

Direct/Indirect Effects to CRLF	Exposure	Application Rate Which Does NOT Exceed LOC (lbs a.i./A)
Direct	Acute Dose-Based Exposures	0.0005
	Acute Dietary-Based Exposures	0.0230
	Chronic Dietary Based Exposures	0.0615
Indirect-mammals	Acute Dose-Based Exposures	0.5000
	Chronic Dose-Based Exposures	0.0048
	Chronic Dietary Based Exposures	0.0415
Indirect-Terrestrial Invertebrates	Acute Contact Exposures (small insect)	0.0007
	Acute Contact Exposures (large insect)	0.0060

AgDRIFT and AGDISP are then used to estimate the distance from the edge of the field of an application site where the concentration will reach 0.0005 lbs a.i./A, indicating no LOC exceedances for terrestrial organisms. The input parameters and detailed results are described in section 3.2.3. For agricultural crops, the maximum distance from the edge of field is 11,617 feet (2.2 miles), which was estimated based on aerial application to lettuce at the maximum single application rate (2 lbs a.i./A). For orchard crops, the maximum distance from the edge of field required to result in no LOC exceedances is 933 feet, which was estimated based on airblast applications to almond crops at the maximum single application rate (3 lbs a.i./A).

To understand the area indirectly affected by the federal action due to spray drift from application areas, the landcovers where agricultural (**Figure 4**) and orchard (**Figure 5**) crops are grown are considered potential application areas. These areas are "buffered" using ArcGIS 9.1. In this process, the original landcover is modified by expanding the border of each polygon representing a field out to a designated distance, which in this case, is the distance estimated where diazinon in spray drift does not exceed any LOCs. This effectively expands the action area relevant to terrestrial habitats so that it includes the area directly affected by the federal action, and the area indirectly affected by the federal action. For diazinon use in agricultural areas, the agricultural use area (**Figure 4**) is buffered using a distance of 11,617 feet (2.2 miles) (**Figure 16**). For diazinon use in orchards, the orchard use area (**Figure 5**) is buffered using a distance of 933 feet (**Figure 17**).

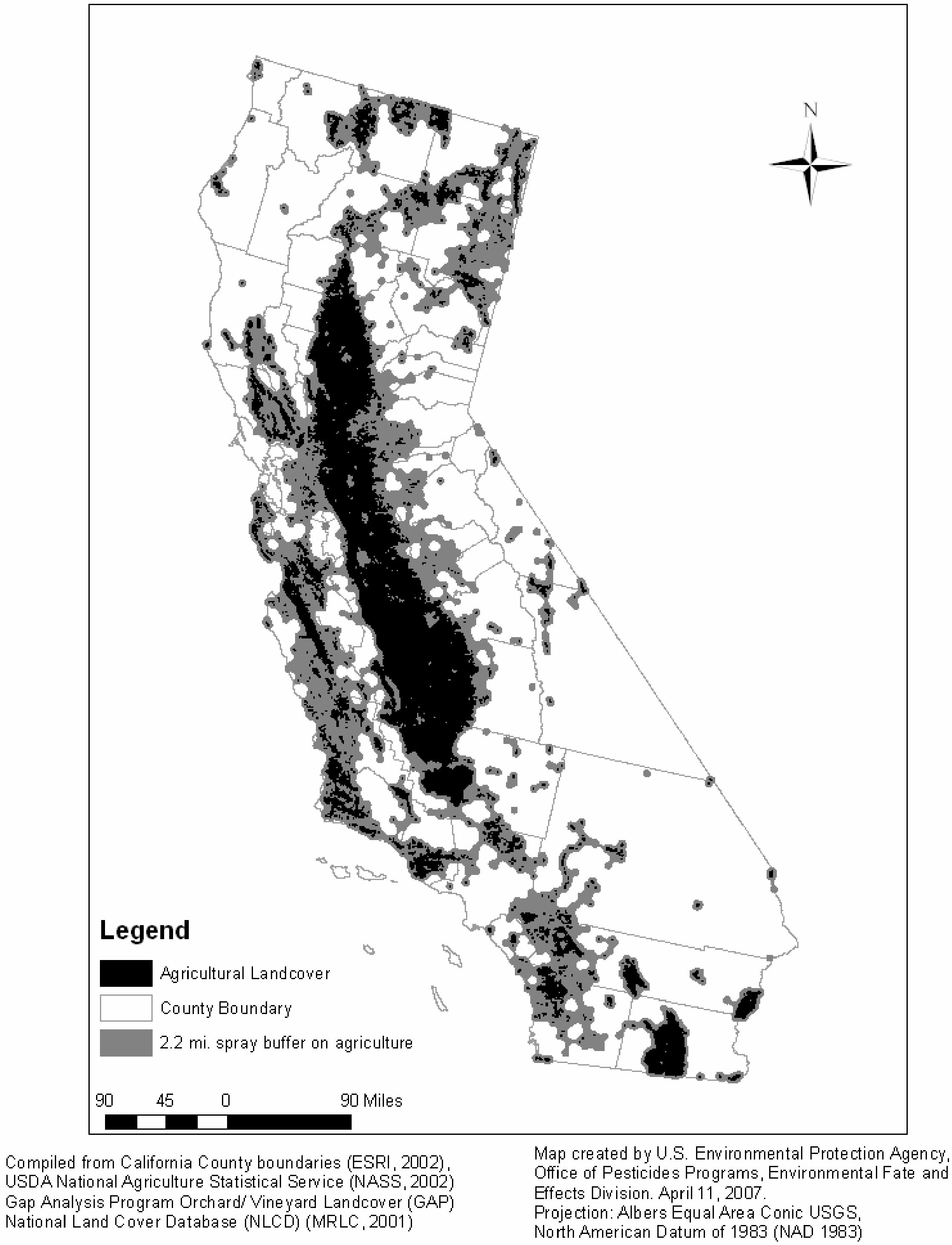
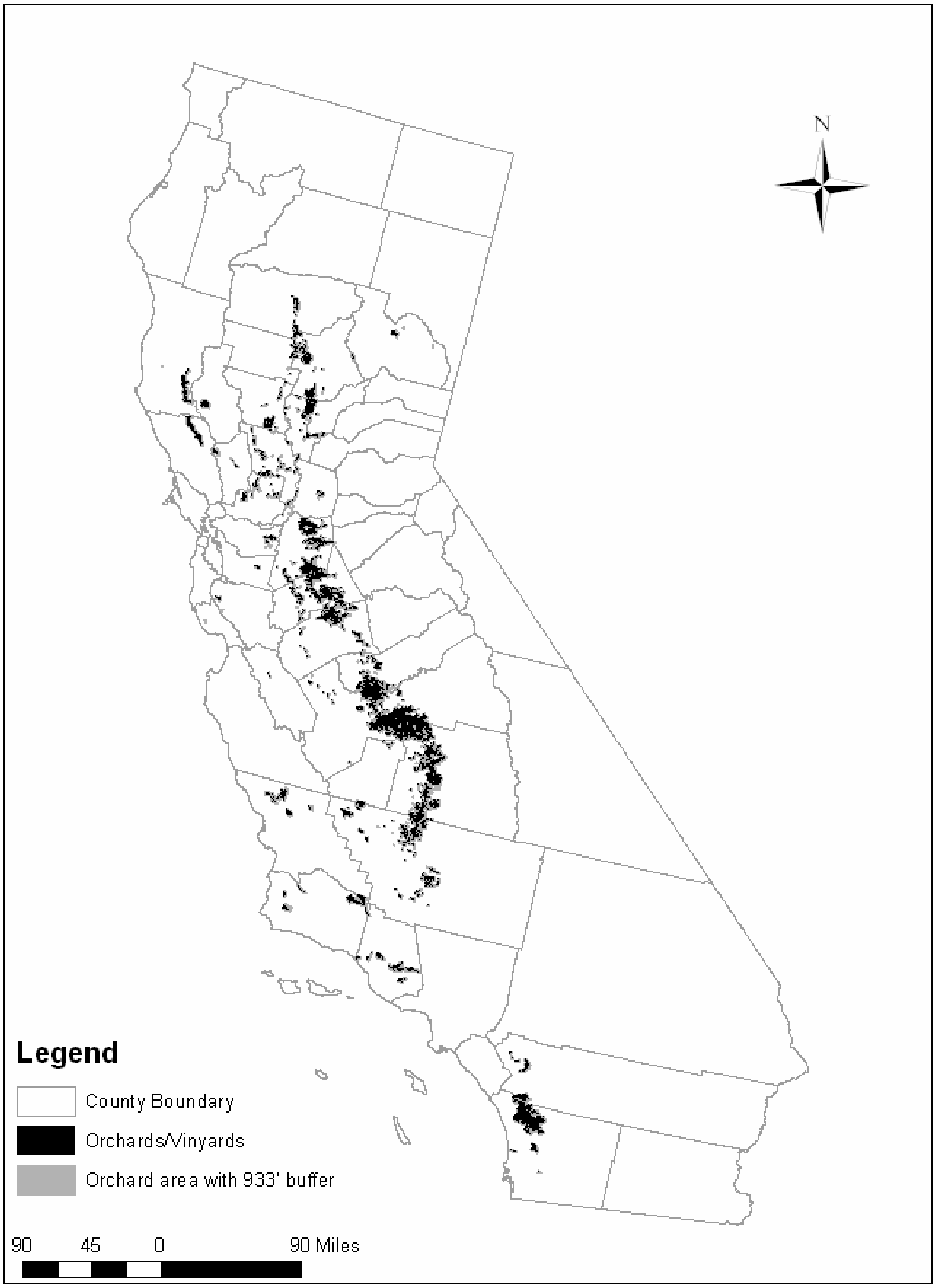


Figure 16. Spray drift relevant to agricultural areas where diazinon is used. Spray drift distance of 2.2 miles is added to the original agriculture use area. Areas potentially directly and indirectly affected by the federal action are depicted.



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

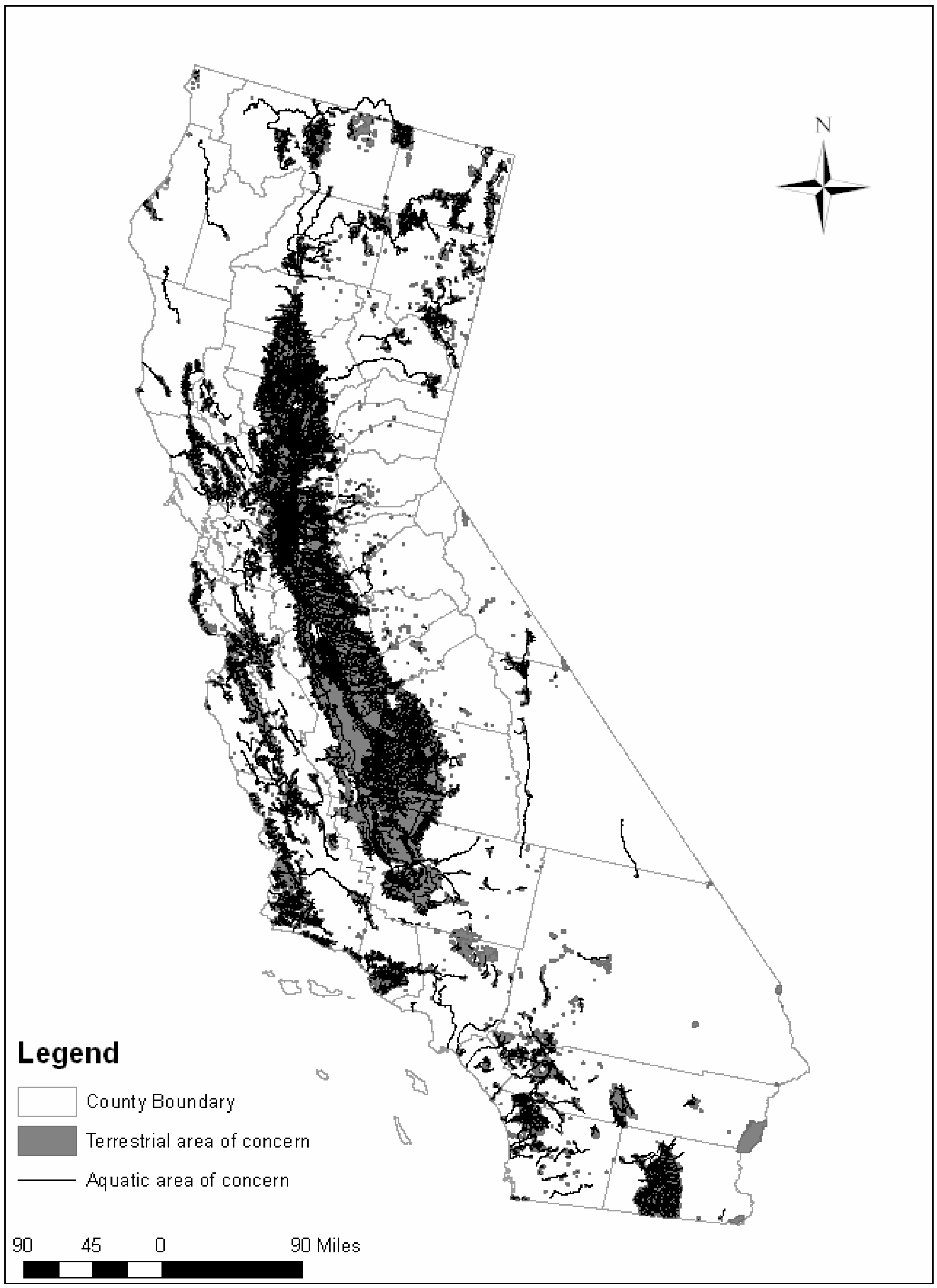
Map created by U.S. Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. April 11, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Figure 17. Spray drift relevant to orchards where diazinon is used. Spray drift distance of 933 feet is added to original orchard use area. Areas potentially directly and indirectly affected by the federal action are depicted.

5.2.5.2. Final action area

In order to define the final action areas relevant to uses of diazinon on agricultural and orchard crops, it is necessary to combine areas directly affected, as well as aquatic and terrestrial habitats indirectly affected by the federal action. This is done separately for agricultural and orchard uses using ArcGIS 9.1. Landcovers representing areas directly affected by diazinon applications are overlapped with indirectly affected aquatic habitats (determined by down stream dilution modeling) and with indirectly affected terrestrial habitats (determined by spray drift modeling). It is assumed that lentic (standing water) aquatic habitats (*e.g.* ponds, pools, marshes) overlapping with the terrestrial areas are also indirectly affected by the federal action. The result is a final action area for diazinon uses in agricultural areas (**Figure 18**) and a final action area for diazinon uses in orchards (**Figure 19**).

As indicated above, agricultural and orchard uses of diazinon could result in deposition of diazinon from the atmosphere which could reach areas outside of the defined action areas for these uses. However, since volatilization, atmospheric transport and deposition are not quantitatively assessed, the implications of these transport mechanisms on the final action area are unknown.



Compiled from California County boundaries (ESRI, 2002), USDA National Agriculture Statistical Service (NASS, 2002) Gap Analysis Program Orchard/ Vineyard Landcover (GAP) National Land Cover Database (NLCD) (MRLC, 2001)

Map created by U.S. Environmental Protection Agency, Office of Pesticides Programs, Environmental Fate and Effects Division. April 11, 2007. Projection: Albers Equal Area Conic USGS, North American Datum of 1983 (NAD 1983)

Figure 18. Final action area relevant to crops represented by agricultural landcover. Aquatic and terrestrial areas affected by the federal action are depicted.

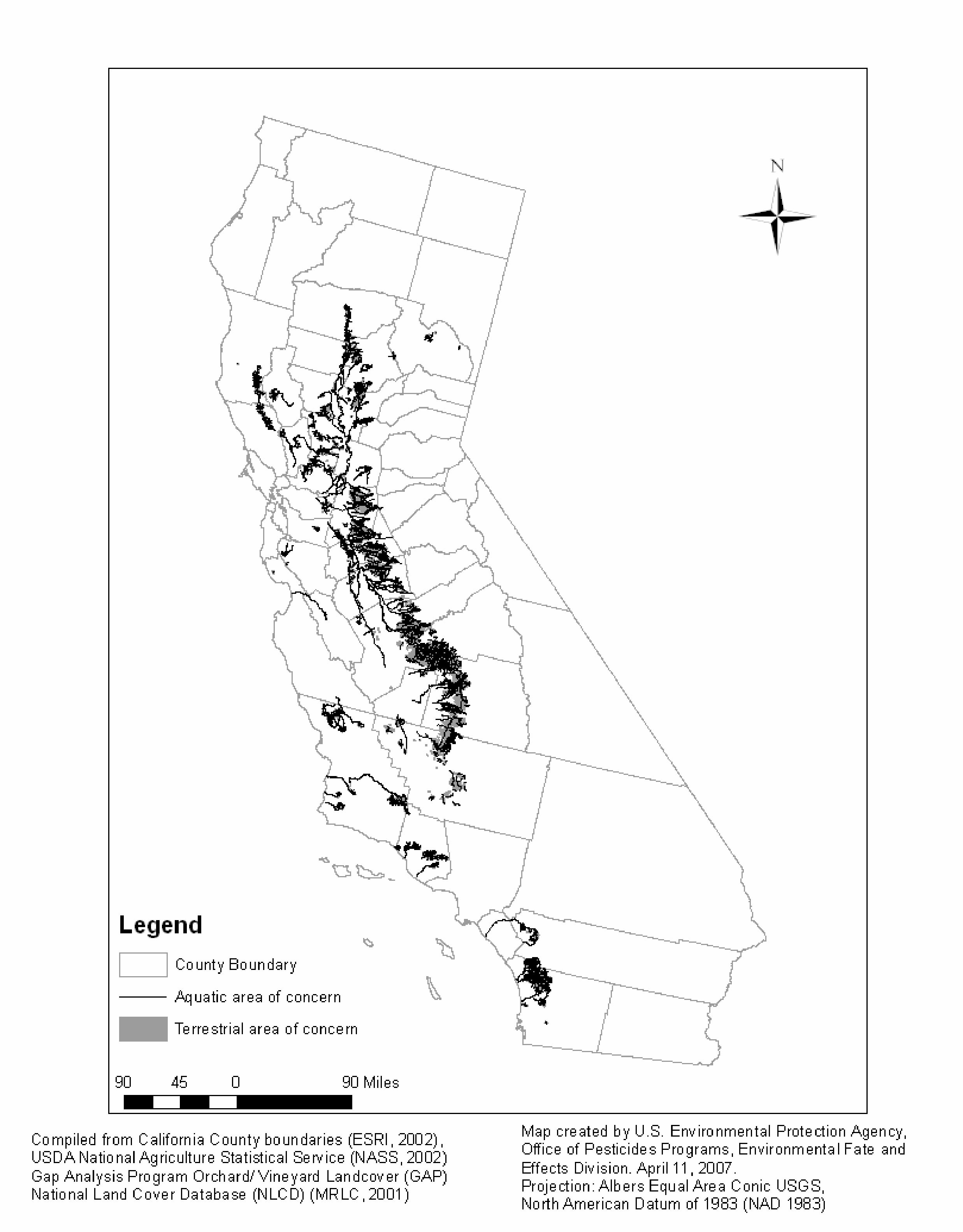


Figure 19. Final action area relevant to crops represented by orchard landcover. Aquatic and terrestrial areas affected by the federal action are depicted.

5.2.5.3. Overlap between CRLF habitat and final action area

In order to confirm that uses of diazinon have the potential to affect CRLF through direct applications to target areas and runoff and spray drift to non-target areas, it is necessary to determine whether or not the final action areas for agricultural and orchard uses of diazinon overlap with CRLF habitats. Spatial analysis using ArcGIS 9.1 indicates that lotic aquatic habitats within the CRLF core areas and critical habitats potentially contain concentrations of diazinon sufficient to result in RQ values that exceed LOCs. In addition, terrestrial habitats (and potentially lentic aquatic habitats) of the final action areas for agricultural and orchard uses of diazinon overlap with the core areas, critical habitat and available occurrence data for CRLF (**Tables 51-52**). Thus, uses of diazinon on agricultural and orchard crops could result in exposures of diazinon to CRLF in aquatic and terrestrial habitats. Additional analysis related to the intersection of the diazinon action area and CRLF habitat is described in **Appendix K**.

Table 51. Overlap between CRLF habitat (core areas and critical habitat) and agricultural action area by recovery unit (RU#).

Measure	RU1	RU2	RU3	RU4	RU5	RU6	RU7	RU8	Total
CRLF habitat (km^2)*	3654	2742	1323	3279	3650	5306	4917	3326	28,197
Overlapping area of CRLF habitat and terrestrial/lentic aquatic action area (km^2)	201	158	111	535	1047	1056	1453	456	5017
% CRLF habitat overlapping with terrestrial/lentic aquatic Action Area	6%	6%	8%	16%	29%	20%	30%	14%	18%
# Occurrences overlapping with terrestrial/lentic aquatic action area	0	0	13	112	186	50	67	0	418

*Area occupied by core areas and/or critical habitat.

Table 52. Overlap between CRLF habitat (core areas and critical habitat) and orchard action area by recovery unit (RU#).

Measure	RU1	RU2	RU3	RU4	RU5	RU6	RU7	RU8	Total
CRLF habitat (km^2)*	3654	2742	1323	3279	3650	5306	4917	3316	28,197
Overlapping area of CRLF habitat and terrestrial/lentic aquatic action area (km^2)	1.7	39	0	24	9	27	120	313	533.7
% CRLF habitat overlapping with terrestrial/lentic aquatic Action Area	0%	1%	0%	1%	0%	1%	2%	9%	2%
# Occurrences overlapping with terrestrial/lentic aquatic action area	0	0	0	11	1	1	8	0	0

*Area occupied by core areas and/or critical habitat.

5.2.6. Incident reports

The original IRED contained a relatively thorough discussion of ecological incidents associated with the use of diazinon up to 2002. The IRED indicates that approximately 239 (IRED Table 86) incidents were reported for diazinon in the Ecological Incident Information System (EIIS) and that from 1979 until 1998, the number of reported incidents was increasing where the majority of reported incidents [where use was known] was associated with diazinon use on turf.

As discussed earlier, a number of use restrictions have been imposed on diazinon subsequent to the interim reregistration eligibility decision. Although there is a total of 492 incidents, of which 79% are associated with effects on terrestrial animals [reported in the EIIS database] there has been a downward trend in the number of reported incidents since risk mitigation measures were imposed beginning in 2003. However, the lack of incident reports cannot be interpreted to mean the lack of incidents. **Figure 20** depicts the yearly number of reported incidents by incident type and illustrates that terrestrial incidents predominated while aquatic incidents, representing roughly 4% of the total reported incidents, were considerably less frequent. As indicated in the IRED, terrestrial incidents, primarily involving bird deaths, continued to show an increasing trend until 2002, after which time the number of reported incidents dropped precipitously. Since 2003 only 3 incidents have been reported, all of which have involved birds. Of the 163 terrestrial incidents where the treatment site is reported, the majority (80%) occurred from residential and turf uses, both of which are now cancelled. The last reported incident involving aquatic animals took place in 2003 and involved the death of 12 fish (I014322-001). For aquatic incidents where the treatment site is reported, roughly 45% have been associated with residential uses while 27% have been associated with orchard uses. The aquatic incident reported in 2003 did not report the treatment area.

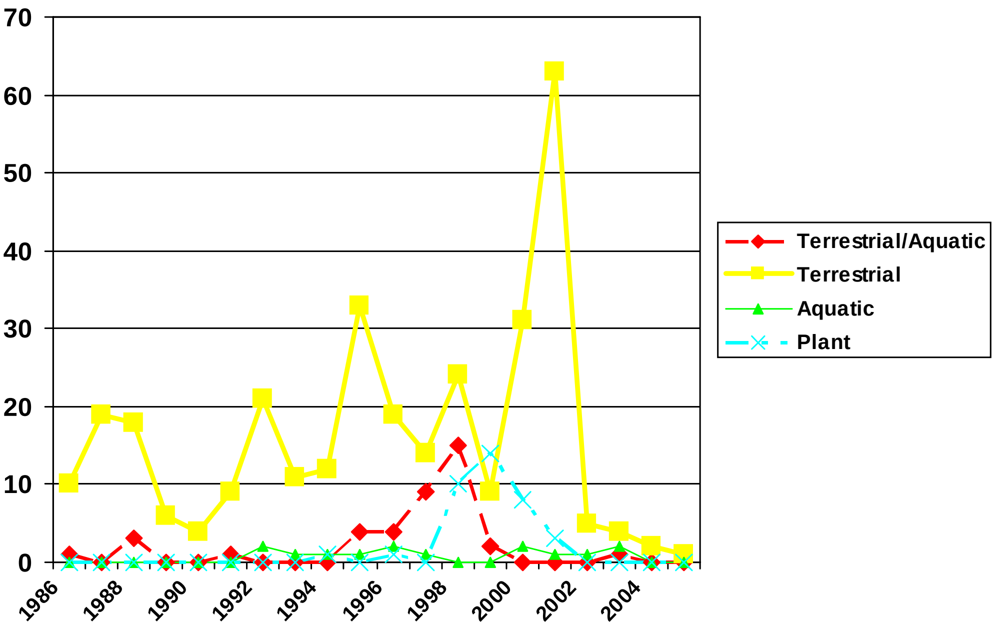


Figure 20. Total number of reported ecological incidents per year involving plants, aquatic animals, terrestrial animals and terrestrial/aquatic animals combined associated with the use of diazinon.

5.2.7. Description of Assumptions, Limitations, Uncertainties, Strengths and Data Gaps

5.2.7.1. Exposure Assessment

The screening-level risk assessment focuses on characterizing potential ecological risks resulting from a maximum use scenario, which is determined from labeled statements of maximum application rate and number of applications with the shortest time interval between applications. The frequency at which actual uses approach this maximum use scenario may be dependant on insecticide resistance, timing of applications, cultural practices, and market forces.

5.2.7.1.1. Aquatic exposure modeling of diazinon

The standard ecological water body scenario (EXAMS pond) used to calculate potential aquatic exposure to pesticides is intended to represent conservative estimates, and to avoid underestimations of the actual exposure. The standard scenario consists of application to a 10-hectare field bordering a 1-hectare, 2-meter deep (20,000 m^3) pond with no outlet. Exposure estimates generated using the EXAMS pond are intended to represent a wide variety of vulnerable water bodies that occur at the top of watersheds including prairie pot holes, playa lakes, wetlands, vernal pools, man-made and natural ponds, and intermittent and lower order streams. As a group, there are factors that make these water bodies more or less vulnerable than the EXAMS pond. Static water bodies that have larger ratios of pesticide-treated drainage area to water body volume would be expected to have higher peak EECs than the EXAMS pond. These water bodies will be either smaller in size or have larger drainage areas. Smaller water bodies have limited storage capacity and thus may overflow and carry pesticide in the discharge, whereas the EXAMS pond has no discharge. As watershed size increases beyond 10-hectares, it becomes increasingly unlikely that the entire watershed is planted with a single crop that is all treated simultaneously with the pesticide. Headwater streams can also have peak concentrations higher than the EXAMS pond, but they likely persist for only short periods of time and are then carried and dissipated downstream.

The Agency acknowledges that there are some unique aquatic habitats that are not accurately captured by this modeling scenario and modeling results may, therefore, under- or over-estimate exposure, depending on a number of variables. For example, aquatic-phase CRLFs may inhabit water bodies of different size and depth and/or are located adjacent to larger or smaller drainage areas than the EXAMS pond. The Agency does not currently have sufficient information regarding the hydrology of these aquatic habitats to develop a specific alternate scenario for the CRLF. As previously discussed in Section 2 and in Attachment 1, CRLFs prefer habitat with perennial (present year-round) or near-perennial water and do not frequently inhabit vernal (temporary) pools because conditions in these habitats are generally not suitable (Hayes and Jennings 1988). Therefore, the EXAMS pond is assumed to be representative of exposure to aquatic-phase CRLFs. In addition, the Services agree that the existing EXAMS pond represents the best currently available approach for estimating aquatic exposure to pesticides (USFWS/NMFS 2004a).

In general, the linked PRZM/EXAMS model produces estimated aquatic concentrations that are expected to be exceeded once within a ten-year period. The Pesticide Root Zone Model is a process or "simulation" model that calculates what happens to a pesticide in a farmer's field on a day-to-day basis. It considers factors such as rainfall and plant transpiration of water, as well as how and when the pesticide is applied. It has two major components: hydrology and chemical transport. Water movement is simulated by the use of generalized soil parameters, including field capacity, wilting point, and saturation water content. The chemical transport component can simulate pesticide application on the soil or on the plant foliage. Dissolved, adsorbed, and vapor-phase concentrations in the soil are estimated by simultaneously considering the processes of pesticide uptake by plants, surface runoff, erosion, decay, volatilization, foliar wash-off, advection, dispersion, and retardation.

Uncertainties associated with each of these individual components add to the overall uncertainty of the modeled concentrations. Additionally, model inputs from the environmental fate degradation studies are chosen to represent the upper confidence bound on the mean values that are not expected to be exceeded in the environment approximately 90 percent of the time. Mobility input values are chosen to be representative of conditions in the environment. The natural variation in soils adds to the uncertainty of modeled values. Factors such as application date, crop emergence date, and canopy cover can also affect estimated concentrations, adding to the uncertainty of modeled values. Factors within the ambient environment such as soil temperatures, sunlight intensity, antecedent soil moisture, and surface water temperatures can cause actual aquatic concentrations to differ for the modeled values.

Unlike spray drift, tools are currently not available to evaluate the effectiveness of a vegetative setback on runoff and loadings. The effectiveness of vegetative setbacks is highly dependent on the condition of the vegetative strip. For example, a well-established, healthy vegetative setback can be a very effective means of reducing runoff and erosion from agricultural fields. Alternatively, a setback of poor vegetative quality or a setback that is channelized can be ineffective at reducing loadings. Until such time as a quantitative method to estimate the effect of vegetative setbacks on various conditions on pesticide loadings becomes available, the aquatic exposure predictions are likely to overestimate exposure where healthy vegetative setbacks exist and underestimate exposure where poorly developed, channelized, or bare setbacks exist.

In order to account for uncertainties associated with modeling, available monitoring data were compared to PRZM/EXAMS estimates of peak EECs for the different uses. As discussed above, several data values were available from NAWQA for diazinon concentrations measured in surface waters receiving runoff from agricultural areas. The specific use patterns (e.g. application rates and timing, crops) associated with the agricultural areas are unknown, however, they are assumed to be representative of potential diazinon use areas. Peak EECs resulting from different diazinon uses ranged 0.6-59.9 µg/L. The maximum concentration of diazinon reported by NAWQA (2000-2005) for California surface waters with agricultural watersheds (1.06 µg/L) was an order of magnitude less than the maximum EEC, but within the range of EECs estimated for different uses. The maximum concentration of diazinon reported by the California Department of Pesticide Regulation surface water database (2000-2005) (15.5 µg/L) is on the same order of magnitude as the highest peak EEC.

When considering 2000-2005 NAWQA monitoring data for California in the context of the effects data, 51.1% of samples (n=255) contained concentrations of diazinon at levels (>0.0105 µg/L) sufficient to exceed the LOC for aquatic invertebrates. In CDPR surface water monitoring data from 2000-2005, diazinon was detected at concentrations sufficient to result in RQ values that exceed the invertebrate acute risk LOC (*i.e.*, >0.0105 µg/L) in 868 samples, which represents 43% of samples. Diazinon was detected at concentrations sufficient to exceed the direct effects acute risk LOC (>4.5µg/L) in 5 samples, which represents 0.2% of the samples (**Figure 13**).

5.2.7.1.2. Terrestrial exposure modeling of diazinon

As indicated above, only foliar applications are considered when assessing EECs for terrestrial phase CRLF and its prey (terrestrial invertebrates, small mammals and frogs), since T-REX is not appropriate for modeling soil applications with incorporation. Therefore, several uses of diazinon in CA are not modeled here, including applications to colecrops, leafy vegetables, root crops, row crops, tomatoes and tuber crops. Although it is possible that CRLF and its prey could be exposed to diazinon applied by soil incorporation, this exposure route is not assessed since it is unlikely that the animals would be foraging in open fields devoid of cover. Therefore, exposure from these uses is expected to be *deminimus*.

The Agency relies on the work of Fletcher et al. (1994) for setting the assumed pesticide residues in wildlife dietary items. These residue assumptions are believed to reflect a realistic upper-bound residue estimate, although the degree to which this assumption reflects a specific percentile estimate is difficult to quantify. It is important to note that the field measurement efforts used to develop the Fletcher estimates of exposure involve highly varied sampling techniques. It is entirely possible that much of these data reflect residues averaged over entire above ground plants in the case of grass and forage sampling.

It was assumed that ingestion of food items in the field occurs at rates commensurate with those in the laboratory. Although the screening assessment process adjusts dry-weight estimates of food intake to reflect the increased mass in fresh-weight wildlife food intake estimates, it does not allow for gross energy differences. Direct comparison of a laboratory dietary concentration-based effects threshold to a fresh-weight pesticide residue estimate would result in an underestimation of field exposure by food consumption by a factor of 1.25 – 2.5 for most food items.

Differences in assimilative efficiency between laboratory and wild diets suggest that current screening assessment methods do not account for a potentially important aspect of food requirements. Depending upon species and dietary matrix, bird assimilation of wild diet energy ranges from 23 – 80%, and mammal's assimilation ranges from 41 – 85% (U.S. Environmental Protection Agency, 1993). If it is assumed that laboratory chow is formulated to maximize assimilative efficiency (e.g., a value of 85%), a potential for underestimation of exposure may exist by assuming that consumption of food in the wild is comparable with consumption during laboratory testing. In the screening process, exposure may be underestimated because metabolic rates are not related to food consumption.

For this baseline terrestrial risk assessment, a generic bird or mammal was assumed to occupy either the treated field or adjacent areas receiving a treatment rate on the field. Actual habitat requirements of any particular terrestrial species were not considered, and it was assumed that species occupy, exclusively and permanently, the modeled treatment area. Spray drift model predictions suggest that this assumption leads to an overestimation of exposure to species that do not occupy the treated field exclusively and permanently.

5.2.7.1.3. Atmospheric transport and deposition

As discussed above, diazinon and has been frequently detected in air and precipitation samples in California. It has been determined that diazinon can be transported miles through the atmosphere before being deposited downwind. Estimates of exposure of the CRLF, its prey and its habitat to diazinon included in this assessment are based only on transport of diazinon through runoff and spray drift from application sites. This assessment does not quantitatively consider additional sources of diazinon exposure due to atmospheric transport. Current estimates of exposures of CRLF and its prey to diazinon through runoff and spray drift, which are already sufficient to exceed the LOC, would be expected to be greater due to deposition from the atmosphere.

Observed concentrations of diazinon in lakes receiving no agricultural runoff (Fellers *et al.* 2004; LeNoir *et al.* 1999) indicate that atmospheric transport could represent a significant source of diazinon exposure to the CRLF and its prey. This exposure alone could potentially exceed the LOC for acute exposures to invertebrates, resulting in potential indirect effects to the CRLF due to acute risks to its prey. Estimates of concentrations of diazinon in the aquatic habitat resulting from wet deposition are sufficient to exceed the LOC for acute exposures to aquatic invertebrates. Estimates of deposition of diazinon in the terrestrial habitat indicate that this transport pathway is sufficient to be of concern for direct effects to the CRLF.

5.2.7.1.4. Additional uses not considered in quantitative EEC derivation

Additional applications per year to Lettuce

Applications to lettuce are allowed up to twice a season. Given that more than one crop of lettuce can be harvested within a year, there is potential for more than two applications of diazinon to lettuce within a year. Due to limitations of the PRZM scenario for lettuce, exposure from only one season was modeled.

Cattle ear tag exposure

As mentioned in the Problem Formulation, there is potential use of diazinon contained in cattle ear tags. Most of the diazinon released from cattle ear tags is expected to volatilize, adsorb to the cow or to soil, or degrade, such that exposure to water bodies is expected to be *deminimus*. Uncertainty in this assumption is based on the extent of cattle ear tag use in proximity to CRLF critical habitat and core areas, including the number of tagged cattle; the rate of tag replacement; the rate of diazinon emission from the tags; the magnitude of dissipation from the tags; and the likelihood of direct aquatic exposure when cattle are in close proximity to CRLF habitats.

SLN CA-050002: Quarantine action for fruit fly pests

In this assessment, the maximum application rate for use on ornamentals allowed by a section 3 label (1 lb a.i./A) is modeled. A single application of diazinon at 1 lb a.i./A to ornamental plants is sufficient to result in exposures to the CRLF and its prey (aquatic invertebrates, fish and aquatic phase frogs) that results in RQ values that exceed the acute and chronic risk LOCs. As stated in the use characterization (Section 2.4.3), SLN CA-050002 actually represents a higher use rate for ornamental crops than modeled in this assessment. The maximum single application rate is 5 lbs a.i./A. Estimated diazinon exposures in aquatic habitats resulting from a single application under this SLN label are greater than those modeled at the 1 lb a.i./A rate. Since estimated exposures resulting from a single application at the lower rate are sufficient to exceed acute and chronic risk LOCs for the CLRF and its prey, it follows that exposures resulting from this SLN are sufficient to be of concern for direct and indirect effects to the CRLF.

According to this SLN, 3 applications of 5 lbs a.i./A can be made at 14-day intervals to treat an infestation. The applications may be repeated if necessary to continue treatment of infestations. Therefore, it is possible that up to 26 applications of 5 lbs a.i./A may be made in one year. In any case, given that a single maximum application is sufficient to be of concern, multiple applications at the 5 lbs a.i./A rate will result in greater exposure and additional concern.

5.2.7.1.4. Degradates

As previously discussed in the effects assessment, the toxicity of the primary degradate of diazinon, oxypyrimidine, is assumed to be less than the parent compound; therefore, RQ values are not derived for exposures to this degradate.

As discussed in the screening-level ecological risk assessment of diazinon (USEPA 2002), the formation of diazoxon was not observed in any of the laboratory biotic or abiotic degradation studies of diazinon. Although there are monitoring data for diazoxon and diazinon in California; these studies do not provide sufficient, consistent information on the levels of the diazoxon degradate relative to the parent. Therefore, it is uncertain what conditions favor the oxon formation and/or persistence in the environment. At this point there is no reasonable way to document the potential risk from diazoxon other than to recognize that the oxon is more toxic than the parent and that the extent to which it may form is uncertain.

Although data indicate that the toxicity of diazoxon is greater than that of the parent, RQ values are not quantified due to a lack of data useful for characterizing the persistence and transport properties of this degradate. It is possible that applications of diazinon could result in exposures of the CRLF, its prey and its habitat to diazoxon. Given that this degradate is an order of magnitude more toxic to amphibians than the parent (Fellars and Sparling 2007), the degradate and parent combined could result in greater risk to the CRLF than through direct or indirect effects from the parent compound alone. However, the effect endpoint (rainbow trout LC_{50}=90 μg/L) used to assess potential direct effects to the CRLF is an order of magnitude more sensitive than the estimated toxicity of diazoxon to aquatic-phase amphibians (96-hr LC_{50}=760 μg/L) and is two orders of magnitude more sensitive that the estimated toxicity of the parent diazinon (96-hr LC_{50}=7488 μg/L) to aquatic-phase amphibians. Therefore, this assessment is considered protective for the potential increased toxicity of the diazoxon degradate to aquatic-phase amphibians.

Monitoring studies in CA have detected diazoxon in air and precipitation samples (**Table 53**). In studies of diazinon and diazoxon concentrations in fog, diazoxon has been observed at greater concentrations than the parent (Schomburg *et al.* 1991). In a study of diazinon and diazoxon concentrations in precipitation in California, diazinon was detected in 93% of rain samples (n=137), with mean and maximum concentrations of 0.149 and 2.220 μg/L, respectively. Diazoxon was measured in 39% of samples (n=137), with mean and maximum concentrations of 0.041 and 0.300 μg/L, respectively (Majewski et al. 2006).

Table 53. Diazoxon detections in air and precipitation samples taken in California.

Location	Year	Sample type	Maximum Conc.*	Source
CA	1980s-1990s	Air	10.8	Reported in Majewski and Capel, 1995
CA	1980s-1990s	Rain	115.8	Reported in Majewski and Capel, 1995
San Joaquin Valley, CA	2002-2004	Rain	300	Majewski et al. 2005
CA	1980s-1990s	Fog	28000	Reported in Majewski and Capel, 1995
Parlier, CA	1986	Fog	4800	Glotfelty *et al.* 1990
Monterey, CA	1987	Fog	11000	Schomburg *et al.* 1991

*For Air, ng/m^3, for rain, snow and fog, ng/L

If diazinon and diazoxon are atmospherically transported and deposited to the habitat of the CRLF, it is possible that the deposition of the degradate is similar to or greater than that of the parent. However, as indicated earlier, neither abiotic or biotic degradation studies of the parent conducted in the laboratory have demonstrated the formation of diazoxon; therefore, the conditions under which the oxygen analog may form is uncertain and at this point there are insufficient data with which to model exposure.

Following the methods described in section 3.3.6, the maximum reported concentration of diazoxon in rain was used to estimate contributions of wet deposition to aquatic and terrestrial habitats. The maximum concentration of 0.3 µg/L was used in combination with California specific precipitation data and PRZM estimated runoff.

For diazinon, concentrations in the aquatic habitat required to exceed the LOC for acute exposures to the CRLF and aquatic invertebrates are 4.5 and 0.0105 µg/L, respectively. Research suggests that diazoxon is approximately 10 times more toxic than diazinon to the yellow-legged frog, which is in the same genus as the CRLF (Sparling and Fellers 2006). If this ratio is transferable to the CRLF and its surrogate fish species, the concentration of diazoxon required to exceed the LOC for CRLF would be 0.45 µg/L. Estimates of diazoxon in the aquatic habitat resulting from wet deposition of observed concentrations of diazoxon in rain are an order of magnitude below this concentration (**Table 54**). Concentrations of diazoxon in precipitation would need to be 3.0 µg/L or greater (i.e. at least 10 times greater) to be of concern for direct effects to the CRLF. Given that this modeling is based on monitoring data that does not necessarily represent high-end concentrations of diazoxon, it is possible that diazoxon could be present in rain at concentrations above 3.0 µg/L, which is sufficient to be of concern for effects to the CRLF. If diazoxon is of equivalent or greater toxicity to aquatic invertebrates compared to diazinon, then the estimated diazoxon concentration in aquatic habitats resulting from deposition of 0.3 µg/L diazoxon in rain would be sufficient to be of concern to these organisms.

Based on toxicity data for birds, it is assumed that diazoxon is of similar toxicity as diazinon to terrestrial organisms. Therefore, estimated concentrations of diazoxon in the terrestrial habitat based on precipitation monitoring data are insufficient to be of concern to CRLF, its prey or its habitat. Concentrations in precipitation would need to be at least 5 times greater to result in levels of concern for direct effects to CRLF in the terrestrial habitat (**Table 54**). Again, given that this modeling is based on monitoring data that does not necessarily represent high-end concentrations of diazoxon, it is possible that diazoxon could be present in rain at concentrations sufficient to be of concern for effects to the CRLF in terrestrial habitats.

Table 54. Estimates of diazoxon concentrations in aquatic and terrestrial habitats resulting from wet deposition.

Met Station	Scenario(s)	Concentration in aquatic habitat (µg/L)	Deposition on terrestrial habitat (lbs a.i./A)
Sacramento	CA almond	0.056	0.0002
Santa Maria	CA lettuce, CA colecrop, CA strawberry	0.060	0.0001
San Francisco	CA winegrape	0.053	0.0002
Monterey Co.	CA row crop	0.048	0.0002
Fresno	CA fruit, CA tomato, CA melon	0.022	0.0001
San Diego	CA nursery	0.041	0.0001
Bakersfield	CA onion, CA potato	0.016	0.0001

5.2.7.1.5. Mixture Effects

This assessment considers only the single active ingredient of diazinon. However, the assessed species and its environments may be exposed to multiple pesticides simultaneously. Interactions of other toxic agents with diazinon could result in additive effects, synergistic effects or antagonistic effects. Evaluation of pesticide mixtures is beyond the scope of this assessment because of the myriad factors that cannot be quantified based on the available data. Those factors include identification of other possible co-contaminants and their concentrations, differences in the pattern and duration of exposure among contaminants, and the differential effects of other physical/chemical characteristics of the receiving waters (*e.g.* organic matter present in sediment and suspended water). Evaluation of factors that could influence additivity/synergism is beyond the scope of this assessment and is beyond the capabilities of the available data to allow for an evaluation. However, it is acknowledged that not considering mixtures could over- or under-estimate risks depending on the type of interaction and factors discussed above.

5.2.7.2. Effects Assessment

5.2.7.2.1. Direct Effects

As previously discussed, direct effects to aquatic-phase CRLF are based on freshwater fish data, which are used as a surrogate for aquatic-phase amphibians. While a limited amount of amphibian data are available, these studies either failed to establish an LC_{50} value or did not report measured concentration values, making them inappropriate for derivation of quantitative RQ values. If RQs are developed based on the nominal concentration LC_{50} value for the yellow legged frog exposed to diazinon (Sparling and Fellers 2006), estimated concentrations in the aquatic habitat would be insufficient to exceed the LOC for direct effects to the CRLF.

Available data suggest that amphibians are considerably less sensitive to diazinon than fish; however, these data also demonstrate that frogs are 10-times more sensitive to diazoxon than to the parent. To the extent to which amphibians are more sensitive than the surrogate species used in this assessment, the assessment is not conservative. By the same token though, to the extent to which diazoxon is present in large quantities in runoff from treated area, the assessment is less conservative in estimating potential effects.

Toxicity data for terrestrial-phase amphibians are not available for use in this assessment. Therefore, avian toxicity data are used as a surrogate for terrestrial-phase CRLF. There is uncertainty regarding the relative sensitivity of amphibians and birds to diazinon. If birds are substantially more or less sensitive than the CRLF, then risk would be over or under estimated, respectively.

5.2.7.2.2. Sublethal Effects

Open literature is useful in identifying sublethal effects associated with exposure to diazinon. These effects include but are not limited to decreased response from olfactory epithelium, effects on heat shock proteins, decreased acetylcholine esterase activity, and effects on endocrine-mediated processes. However, no data are available to link the sublethal measurement endpoints to direct mortality or diminished reproduction, growth and survival that are used by OPP as assessment endpoints. While the study by Scholz *et al*. 2003 attempted to relate the results of olfactory perfusion assays to decreased predator avoidance and homing response in salmon, the study results are not sufficiently vetted to establish a clear dose-dependent relationship. OPP acknowledges that a number of sublethal effects have been associated with diazinon exposure; however, at this point there are insufficient data to definitively link the measurement endpoints to assessment endpoints. To the extent to which sublethal effects are not considered in this assessment, the potential direct and indirect effects of diazinon on CRLF may be underestimated.

For an acute risk assessment, the screening risk assessment relies on the acute mortality endpoint as well as a suite of sublethal responses to the pesticide, as determined by the testing of species response to chronic exposure conditions and subsequent chronic risk assessment. Consideration of additional sublethal data in the assessment is exercised on a case-by-case basis and only after careful consideration of the nature of the sublethal effect measured and the extent and quality of available data to support establishing a plausible relationship between the measure of effect (sublethal endpoint) and the assessment endpoints.

5.2.7.2.3. Indirect Effects

Indirect effects on the aquatic-phase CRLF are estimated based on the most sensitive invertebrate tested, *i.e.*, *Ceriodaphnia dubia*. Other, less sensitive, aquatic invertebrates may be part of the diet of the aquatic phase CRLR. Therefore, risk to *C. dubia*, may not be equivalent to risk to organisms comprising the diet of the CRLF. This uncertainty is explored further using genus sensitivity distributions of available toxicity data for diazinon.

5.2.7.2.4. Sensitivity Distributions

In order to characterize the conservativeness of the endpoints selected to represent direct effects to aquatic-phase CRLF (*e.g.* rainbow trout LC_{50} = 90 μg/L), direct effects to terrestrial-phase CRLF (e.g. mallard duck LD_{50} = 1.44 mg/kg) and indirect effects to the CRLF through direct effects to its aquatic prey (*e.g. C. dubia* EC_{50} = 0.21 μg/L) genus sensitivity distributions are derived using the available acute toxicity data for freshwater fish, birds and invertebrates, respectively.

A quantitative distribution is established for each group. Data are considered useful for the quantitative distributions if they are classified acceptable or supplemental. Once a data set is assembled, the average of the Log10 values of the LC_{50} values for a species is calculated. Then, the average of the Log10 values of the genera is estimated. A semi-lognormal distribution is used to estimate the sensitivity distribution by considering the mean and standard deviation of all genus mean values. A full description of the data and results used to derive these distributions is included in **Appendix F**.

In order to consider the distribution in context of the exposure and the LOC, aquatic EECs are adjusted by dividing the EEC by the LOC (0.05) for acute exposures. The resulting concentrations range 12.6-1189.7 μg/L for fig and lettuce (2 applications), respectively (**Table 55**). This range of concentrations represents the maximum value of the EC_{50} that would result in an exceedance of the LOC. In other words, an EC_{50} greater than this range would not be expected to result in direct or indirect effects to the CRLF.

Table 55. Aquatic EECs from PRZM/EXAMS modeling for maximum application rates of diazinon. Acute EECs are adjusted by dividing the EEC by the acute LOC.

Uses	Application # and type	Peak EEC (µg/L)	Adjusted Peak EEC (µg/L)
Fig	1 foliar	0.63	12.6
Blueberries	1 fire ant	1.43	28.6
Blueberries	1 foliar	1.49	29.8
Melons [3]	1 foliar	2.48	49.6
Tree fruit [6]	1 foliar	2.53	50.5
Blueberries	2 foliar	2.61	52.3
Caneberries	1 foliar	2.98	59.7
Melons [3]	1 soil incorp	3.32	66.3
Melons [3]	2 foliar	4.92	98.4
Tree fruit [6]	1 foliar + 1 dormant	6.70	134.0
outdoor ornamentals	1 foliar	6.79	135.8
Tree fruit [6]	1 dormant	7.16	143.3
Almonds	1 foliar	9.10	182.1
Tomatoes	1 soil incorp	10.31	206.2
Strawberries	1 soil incorp	11.23	224.6
Tuber crops [7]	1 soil incorp	11.40	228.0
Root crops [4]	1 soil incorp	12.10	242.1
Almonds	1 dormant	15.63	312.6
Row crops [5]	1 soil incorp	16.32	326.3
Strawberries	1 foliar	21.41	428.2
Cole crops[1]	1 soil incorp	24.10	482.0
Strawberries	2 foliar	26.53	530.5
Lettuce	1 soil incorp	27.37	547.4
Lettuce	1 aerial foliar	30.85	617.1
Outdoor ornamentals	26 foliar	49.90	998.1
Leafy vegetables[2]	1 soil incorp	54.74	1094.9
Lettuce	2 aerial foliar	59.48	1189.7

[1] broccoli, Brussels sprouts, cabbage, cauliflower, collards, kale, mustard greens

[2] spinach, endive

[3] cantaloupes, casabas, crenshaws, honeydews, muskmelons, persians, watermelons

[4] onion, radishes

[5] carrots, beans, peppers (bell and chili), peas (succulent), beets (red)

[6] apples, apricots, cherries, fig, nectarines, peaches, pears, plums, prunes

[7] rutabagas, sweet potatoes

The number of data points, species and genera incorporated into each of the three sensitivity distributions are identified in **Table 56**. The curves of the sensitivity distributions are represented by **Figures 21-23**. In the figures, each point represents the genus mean value for the respective genus and the solid line represents the sensitivity distribution based on these data.

Table 56. Numbers of data points, species and geneses incorporated into each of the sensitivity distributions. The lower 95th percentile estimates of EC_{50} values relevant to the distributions are also included.

Taxa	Number of Data Values	Number of Species	Number of Genuses	Toxicity endpoint for assessment	Lower 95th Percentile
Fish	11	9	7	90 µg/L	139 µg/L
Birds	17	7	7	1.44 mg/kg	1 mg/kg
Invertebrates	9	7	6	0.21 µg/L	0.13 µg/L

The lower 95th percentile of the fish distribution (139 µg/L) indicates that the use of the lowest available toxicity value (90 µg/L) is likely a conservative estimate of the toxicity of diazinon to freshwater vertebrates. When considering the maximum of the range of adjusted exposure values (1189.7 µg/L), there is risk to genuses below the 60th percentile of the distribution.

The lower 95th percentile of the bird distribution (1 mg/kg) indicates that the use of the lowest available toxicity value (1.44 mg/kg) is not as conservative as the value used for birds. It is however, within the lower 90th percentile of sensitive genuses (<2 mg/kg).

The lower 95th percentile of the invertebrate distribution (0.13 µg/L) indicates that the use of the lowest available toxicity value (0.21 µg/L) is not as conservative as the value used for invertebrates. It is however, within the lower 90th percentile of sensitive genuses (<0.26 µg/L). When considering the adjusted exposure values, there is risk to the majority genuses (>70% for all uses) for which there is quantitative data.

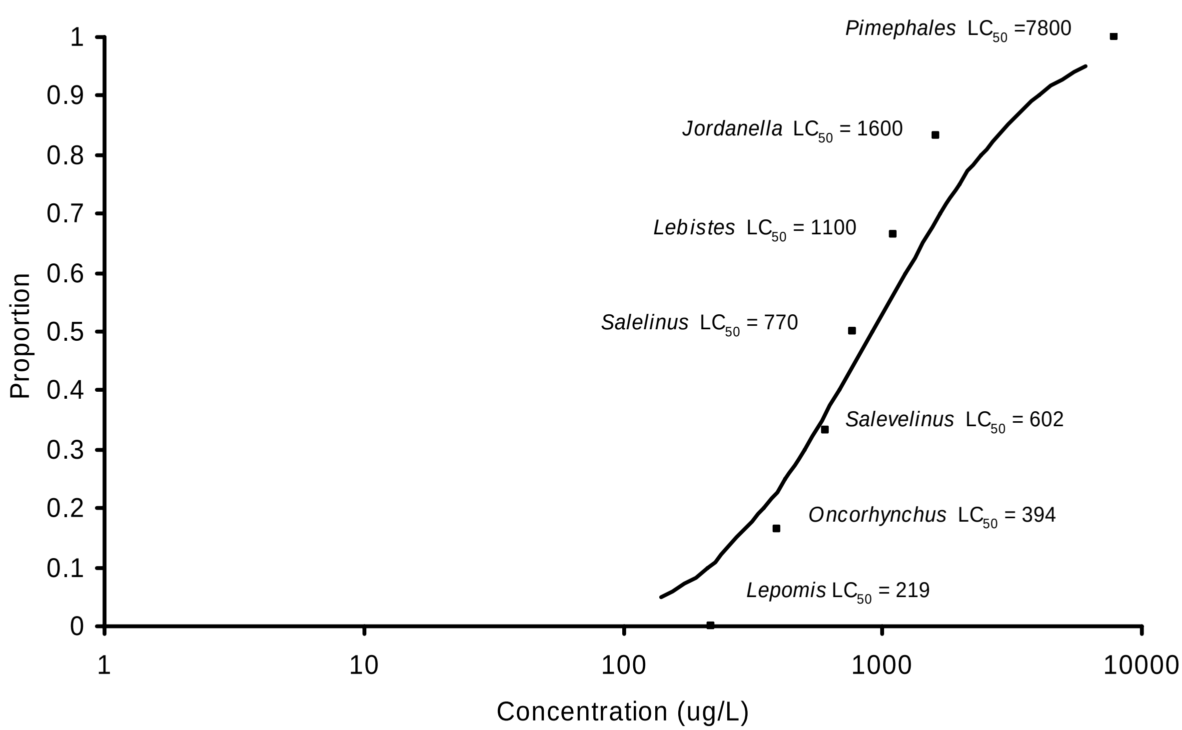


Figure 21. Fish sensitivity distribution of toxicity data considered useful for quantitative purposes.

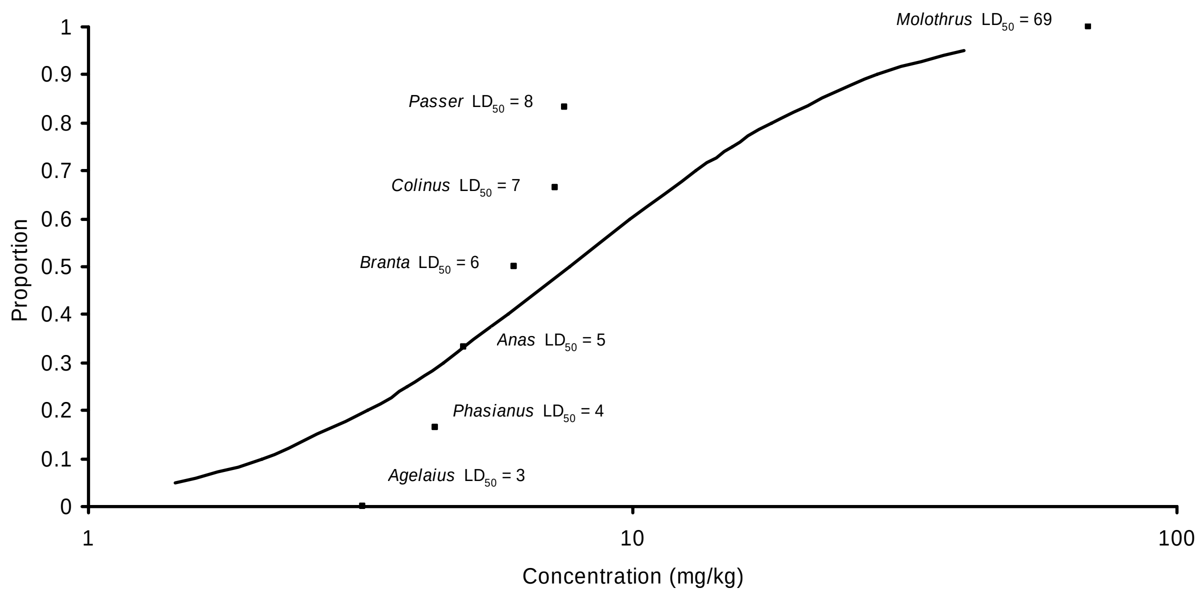


Figure 22. Bird sensitivity distribution of toxicity data considered useful for quantitative purposes.

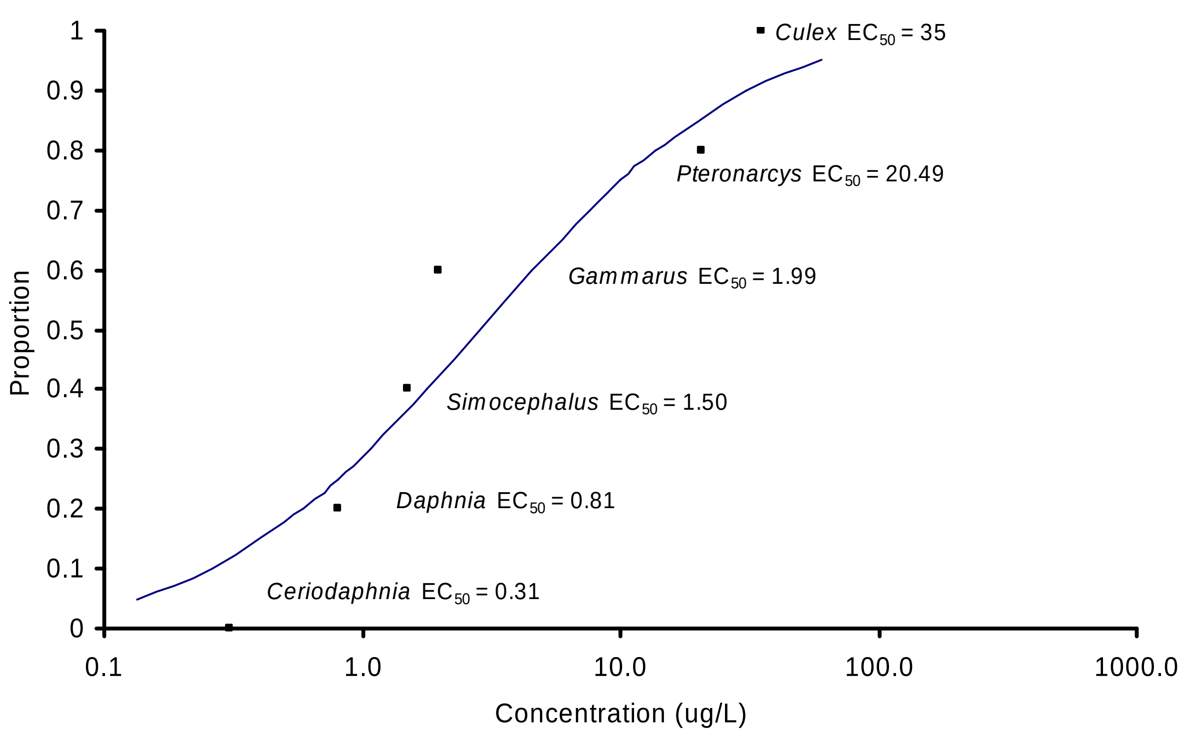


Figure 23. Invertebrate sensitivity distribution of toxicity data considered useful for quantitative purposes.

5.2.7.2.5. Age Class and Sensitivity of Effects Thresholds

It is generally recognized that test organism age may have a significant impact on the observed sensitivity to a toxicant. The acute toxicity data for fish are collected on juvenile fish between 0.1 and 5 grams. Aquatic invertebrate acute testing is performed on recommended immature age classes (e.g., first instar for daphnids, second instar for amphipods, stoneflies, mayflies, and third instar for midges).

Testing of juveniles may overestimate toxicity at older age classes for pesticide active ingredients that act directly without metabolic transformation because younger age classes may not have the enzymatic systems associated with detoxifying xenobiotics. In so far as the available toxicity data may provide ranges of sensitivity information with respect to age class, this assessment uses the most sensitive life-stage information as measures of effect for surrogate aquatic animals, and is therefore, considered as protective of the California Red Legged Frog.

5.2.7.3. Action Area

An example of an important simplifying assumption that may require future refinement is the assumption of uniform runoff characteristics throughout a landscape. It is well documented that runoff characteristics are highly non-uniform and anisotropic, and become increasingly so as the area under consideration becomes larger. The assumption made for estimating the aquatic Action Area (based on predicted in-stream dilution) was that the entire landscape exhibited runoff properties identical to those commonly found in agricultural lands in this region. However, considering the vastly different runoff characteristics of: a) undeveloped (especially forested) areas, which exhibit the least amount of surface runoff but the greatest amount of groundwater recharge; b) suburban/residential areas, which are dominated by the relationship between impermeable surfaces (roads, lots) and grassed/other areas (lawns) plus local drainage management; c) urban areas, that are dominated by managed storm drainage and impermeable surfaces; and d) agricultural areas dominated by Hortonian and focused runoff (especially with row crops), a refined assessment should incorporate these differences for modeled stream flow generation. As the zone around the immediate (application) target area expands, there will be greater variability in the landscape; in the context of a risk assessment, the runoff potential that is assumed for the expanding area will be a crucial variable (since dilution at the outflow point is determined by the size of the expanding area). Thus, it important to know at least some approximate estimate of types of land use within that region. Runoff from forested areas ranges from 45 – 2,700% less than from agricultural areas; in most studies, runoff was 2.5 to 7 times higher in agricultural areas (e.g., Okisaka et al., 1997; Karvonen et al., 1999; McDonald et al., 2002; Phuong and van Dam 2002). Differences in runoff potential between urban/suburban areas and agricultural areas are generally less than between agricultural and forested areas. In terms of likely runoff potential (other variables – such as topography and rainfall – being equal), the relationship is generally as follows (going from lowest to highest runoff potential):
Three-tiered forest < agroforestry < suburban < row-crop agriculture < urban.

There are, however, other uncertainties that should serve to counteract the effects of the aforementioned issue. For example, the dilution model considers that 100% of the agricultural area has the chemical applied, which is almost certainly a gross over-estimation. Thus, there will be assumed chemical contributions from agricultural areas that will actually be contributing only runoff water (dilutant); so some contributions to total contaminant load will really serve to lessen rather than increase aquatic concentrations. In light of these (and other) confounding factors, Agency believes that this model gives us the best available estimates under current circumstances.

5.2.7.4. Use Data

County-level usage data were obtained from California's Department of Pesticide Regulation Pesticide Use Reporting (CDPR PUR) database. Four years of data (2002 – 2005) were included in this analysis because statistical methodology for identifying outliers, in terms of area treated and pounds applied, was provided by CDPR for these years only. No methodology for removing outliers was provided by CDPR for 2001 and earlier pesticide data; therefore, this information was not included in the analysis because it may misrepresent actual usage patterns. CDPR PUR documentation indicates that errors in the data may include the following: a misplaced decimal; incorrect measures, area treated, or units; and reports of diluted pesticide concentrations. In addition, it is possible that the data may contain reports for pesticide uses that have been cancelled. The CPDR PUR data does not include home owner applied pesticides; therefore, residential uses are not likely to be reported. As with all pesticide use data, there may be instances of misuse and misreporting. The Agency made use of the most current, verifiable information; in cases where there were discrepancies, the most conservative information was used.

5.2.7.5. General Uncertainties

When evaluating the significance of this risk assessment's direct/indirect and adverse habitat modification effects determinations, it is important to note that pesticide exposures and predicted risks to the species and its resources (i.e., food and habitat) are not expected to be uniform across the action area. In fact, given the assumptions of drift and downstream transport (i.e., attenuation with distance), pesticide exposure and associated risks to the species and its resources are expected to decrease with increasing distance away from the treated field or site of application. Evaluation of the implication of this non-uniform distribution of risk to the species would require information and assessment techniques that are not currently available. Examples of such information and methodology required for this type of analysis would include the following:

- Enhanced information on the density and distribution of CRLF life stages within specific recovery units and/or designated critical habitat within the action area. This information would allow for quantitative extrapolation of the present risk assessment's predictions of individual effects to the proportion of the population extant within geographical areas where those effects are predicted. Furthermore, such population information would allow for a more comprehensive evaluation of the significance of potential resource impairment to individuals of the species.

- Quantitative information on prey base requirements for individual aquatic- and terrestrial-phase frogs. While existing information provides a preliminary picture of the types of food sources utilized by the frog, it does not establish minimal requirements to sustain healthy individuals at varying life stages. Such information could be used to establish biologically relevant thresholds of effects on the prey base, and ultimately establish geographical limits to those effects. This information could be used together with the density data discussed above to characterize the likelihood of adverse effects to individuals.
- Information on population responses of prey base organisms to the pesticide. Currently, methodologies are limited to predicting exposures and likely levels of direct mortality, growth or reproductive impairment immediately following exposure to the pesticide. The degree to which repeated exposure events and the inherent demographic characteristics of the prey population play into the extent to which prey resources may recover is not predictable. An enhanced understanding of long-term prey responses to pesticide exposure would allow for a more refined determination of the magnitude and duration of resource impairment, and together with the information described above, a more complete prediction of effects to individual frogs and potential adverse modification to critical habitat.

5.2.8. Addressing the Risk Hypotheses

In order to conclude this risk assessment, it is necessary to address the risk hypotheses defined in section 2.9.1. Based on the results of this assessment, several hypotheses can be rejected, meaning that they are not of concern for the CRLF. However, several of the original hypotheses cannot be rejected, meaning that the statements represent concerns in terms of effects of diazinon on the CRLF.

Based on the results of this assessment, the following hypotheses <u>can</u> be rejected:

- Labeled uses of diazinon within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;

- Labeled uses of diazinon within the action area may indirectly affect the CRLF and/or adversely modify designated critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) required to maintain acceptable water quality and habitat in the ponds and streams comprising the species' current range and designated critical habitat;

- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.

- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.

- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing or changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation).

Based on the results of this assessment, the following hypotheses can not be rejected.

- Labeled uses of diazinon within the action area may directly affect the CRLF by causing mortality or by adversely affecting growth or fecundity;

- Labeled uses of diazinon within the action area may indirectly affect the CRLF by reducing or changing the composition of food supply;

- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;

- Labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs.

6. Conclusions

Based on estimated environmental concentrations for the currently registered uses of diazinon, RQ values are above the Agency's LOC for direct acute and chronic effects on the CRLF. RQs exceed the LOC for acute and chronic risks to aquatic invertebrates and for acute risk to terrestrial invertebrates. When considering the prey of larger CRLF in aquatic and terrestrial habitats (e.g. frogs, fish and small mammals), RQs for these taxa also exceed the LOC for acute and chronic risk. Based on these LOC exceedances, the initial effect determination is "may affect." Consideration of surface water monitoring data, species sensitivity distributions and likelihood of individual mortality of the CRLF and its various prey were used to further define the effect determination as "likely to adversely affect," based on direct effects to the CRLF in its aquatic and terrestrial habitats as well as indirect effects to the CRLF through effects to its prey in aquatic and terrestrial habitats (See **Tables 57 and 58**). In addition, labeled uses of diazinon within the action area may adversely modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal growth and viability of juvenile and adult CRLFs and their food source.

RQ values for plants in aquatic and terrestrial habitats do not exceed the LOCs; therefore, indirect effects to the CRLF through effects on aquatic and terrestrial habitats is a "no effect" (NE) determination.

Based on the conclusions of this assessment, a formal consultation with the U. S. Fish and Wildlife Service under Section 7 of the Endangered Species Act should be initiated to seek concurrence with the LAA determinations for the California red-legged frog and to determine whether there are reasonable and prudent alternatives and/or measures to reduce and/or eliminate potential incidental take associated with the registered uses of diazinon.

Table 57. Diazinon use-specific direct effects determinations[1] for the CRLF.

Use	Aquatic-phase		Terrestrial-phase	
	Acute	Chronic	Acute	Chronic
Almonds	LAA	LAA	LAA	LAA
Blueberries	NE	LAA	LAA	LAA
Cole crops	LAA	LAA	NE	NE
Cranberries	NE	LAA	LAA	LAA
Fig	NE	NE	LAA	LAA
Leafy vegetables	LAA	LAA	NE	NE
lettuce	LAA	LAA	LAA	LAA
Melons	LAA	LAA	LAA	LAA
outdoor ornamentals	LAA	LAA	LAA	LAA
Root crops	LAA	LAA	NE	NE
Row crops	LAA	LAA	NE	NE
strawberries	LAA	LAA	LAA	LAA
tomatoes	LAA	LAA	NE	NE
Tree fruit	LAA	LAA	LAA	LAA
Tuber crops	LAA	LAA	NE	NE

[1]LAA = likely to adversely affect; NE = no effect

Table 58. Diazinon use-specific indirect effects determinations[1] based on effects to prey.

Use	Algae	Aquatic Invertebrates		Terrestrial Invertebrates (Acute)	Aquatic phase frogs and fish		Terrestrial-phase frogs		Small Mammals	
		Acute	Chronic		Acute	Chronic	Acute	Chronic	Acute	Chronic
Almonds	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Blueberries	NE	LAA	LAA	LAA	NE	LAA	LAA	LAA	NLAA	LAA
Cole crops	NE	LAA	LAA	NE	NE	LAA	NE	NE	NE	NE
Cranberries	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Fig	NE	LAA	LAA	LAA	NE	NE	LAA	LAA	NLAA	LAA
Leafy vegetables	NE	LAA	LAA	NE	LAA	LAA	NE	NE	NE	NE
lettuce	NE	LAA	LAA	LAA	LAA	LAA	LAA	LAA	NLAA	LAA
Melons	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
outdoor ornamentals	NE	LAA	LAA	LAA	LAA	LAA	LAA	LAA	NLAA	LAA
Root crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
Row crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
strawberries	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
tomatoes	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE
Tree fruit	NE	LAA	LAA	LAA	NLAA	LAA	LAA	LAA	NLAA	LAA
Tuber crops	NE	LAA	LAA	NE	NLAA	LAA	NE	NE	NE	NE

[1]LAA = likely to adversely affect; NLAA = not likely to adversely affect; NE = no effect

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8. Appendices (Included as Separate Document)